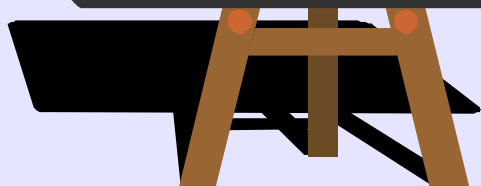


# Chemistry Tests

## Answers

There are six electrons  
in a carbon atom



## Dr David's Chemistry Test (Answers)

### Test 1 (answers): Theme: Atomic Structure.

1. Protons,
2. Negative, one two thousandth.
3. Neutrons.
4.  $x=23$ ,  $y=11$ .
5. Electrons, shells.
6. Spherically symmetrical and dumb-belled shaped.
7. Singly positively, detector, mass.
8. Energy required to remove an electron from 1 mole of gaseous atoms.
9.  $\text{Cl(g)} + \text{e}^- \longrightarrow \text{Cl}^-\text{(g)}$ .
10. 100, 0.125g.

## Test 2 (answers): Theme: Atomic Structure, Moles.

1. (a ) 15, (b) 31, (c ) 16.
2. (I) 18, (ii) 20, (iii) 20.
3. 0.106M.
4. To make you aware of any potential dangers in the proposed experimental work.
5. Sometimes pipettes have water in them which needs to be removed before the pipette is used to measure out the reagent.
6. Brick red.
7. 2 and 3:1.
8. A region of space about the nucleus in which there is greatest probability of finding a particular electron. S orbital is spherically symmetrical about the nucleus. P orbital is dumb bell shaped and centred about the nucleus.
9. Deflects positively charged particles according to mass.
10. That quantity of a substance containing as many particles as there are atoms in 12g of carbon-twelve, (i)  $6 \times 10^{23}$  (ii) 23g.

### Test 3 (answers): Theme: Atomic Structure, Formulae.

1.  $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$  , chlorine.

2. (i) 10, (ii) 9, (iii) 10.

3.  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s}) \longrightarrow \text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{g})$  .

4. Flame test - bright yellow.

5. 
$$\text{RIM} = \frac{\text{mass of an atom of the isotope}}{\text{mass of } 1/12 \text{ of an atom of } ^{12}\text{C}}$$

6. 6.

7.  $\text{Na}_2\text{CO}_3, \text{Al}(\text{NO}_3)_3, \text{KCl}, \text{H}_2\text{SO}_4$ .

8.  $\text{M}(\text{g}) \longrightarrow \text{M}^+(\text{g}) + \text{e}^-$  , electrons drawn in towards the nucleus, atoms get smaller, therefore more energy required to remove the outer electron.

9. To form a singly positively charged ion by removing an electron from an atomic or molecular particle by bombardment with high energy electrons from a hot filament.

10.

$$\text{RAM} = \frac{\text{average mass of an atom of the element}}{\text{mass of } 1/12 \text{ of an atom of } ^{12}\text{C}}$$

#### Test 4 (answers): Theme: Atomic Structure, Formulae.

1.  $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^1$  .

2. Oxygen, ozone.

3. Bubble the gas into lime water. The solution changes from clear and colourless to milky white (continuing to pass the gas produces a clear and colourless solution), sodium hydrogencarbonate (bicarbonate) and calcium carbonate.

4. Flame test - lilac coloured flame.

5. Concentration of a solution in moles per  $\text{dm}^3$ .  $M = \frac{\text{g/dm}^3}{\text{RMM}}$

6. Ionic & covalent.

7.  $\text{HNO}_3$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{CHCl}_3$ ,  $\text{CaCl}_2$ .

8.  $\text{E}(\text{g}) + \text{e}^- \longrightarrow \text{E}^-(\text{g})$

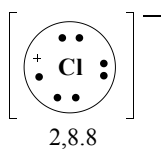
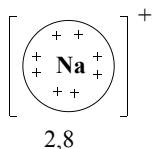
9.  $\text{C}_2\text{H}_5$ , C=75%, H=25%.

10.  $\text{Zn}(\text{s}) + 2\text{H}^+(\text{aq}) \longrightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$

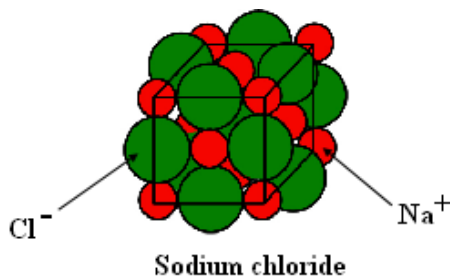
## Test 5 (answers): Bonding, Formulae.

1. The ion distorts the electron cloud associated with adjacent anions. It exhibits this property because it has a high charge density, ie., it is a small highly charge ion ( $\text{Al}^{3+}$ ).

2.

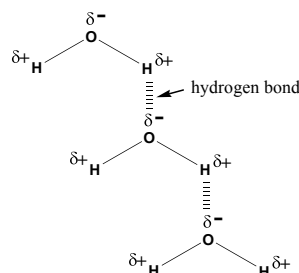
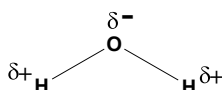


3.

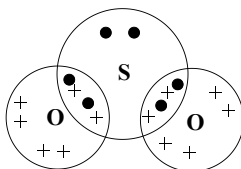
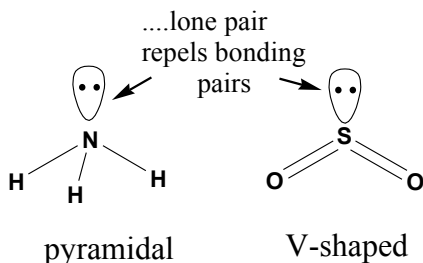


Cubic arrangement

4. Positive and negative ends -



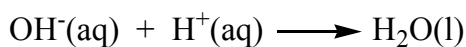
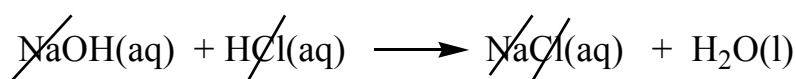
5.



6. Pi bonds are weaker and more easily broken than sigma bonds. Pi bonds are formed by the side ways overlap of p orbitals and they are often described as being doughnut shaped.

7. The average mass of an atom of an element compared with the mass of an atom of carbon-12 on the scale where  $^{12}\text{C} = 12.0000$  mass units.

8.



9.

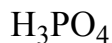
$$0.2 \text{ mol} \equiv 22.0 \text{ g}$$

$$1 \text{ mol} \equiv 110 \text{ g}$$

therefore, mol. formula = 2 x emp. formula (KO)

ie,  $\text{K}_2\text{O}_2$

10.



## Test 6 (answers): Theme: Bonding, Formulae.

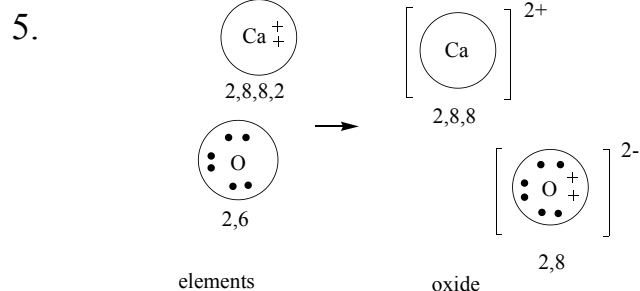
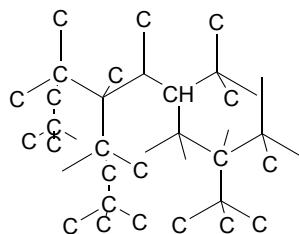
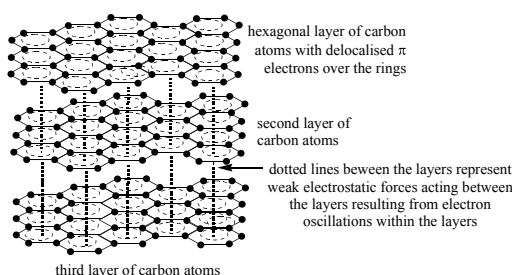
1. They have s electrons in their outer shells. Al. Magnesium (MgO), Sulphur (SO<sub>2</sub>).

2. Potassium. KO<sub>2</sub>.



3. S<sub>8</sub> molecules have more electrons and greater van der Waal attractions than Cl<sub>2</sub> molecules. The relatively weak attractive forces between chlorine molecules accounts for its gaseous nature compared with sulphur which is a yellow solid at room temperature and pressure.

4. Graphite a covalent layer structure, diamond a giant covalent network structure.



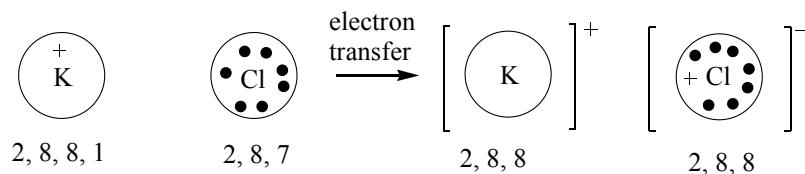
6 Decrease from Be to Ba. The atoms increase in size and their outer electrons occur further away from the nucleus and are held less strongly. Also there is an increase in the number of completed shells between the nucleus and outer electrons giving rise to increased *shielding* so reducing the hold of the nucleus on the outer electrons. For these reasons less energy is required to remove outer electrons from Be to Ba.

7.



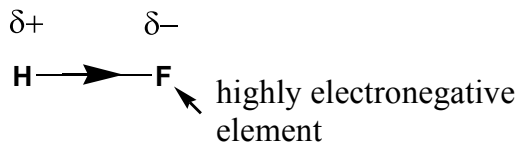
## Test 7 (answers): Theme: Bonding

1.



2. Low melting point, low solubility in water, poor heat and electrical conductivities.

3. This is a measure of the ability of an atom of an element to attract electrons along a covalent bond. eg,



4. It is the ability of the aluminium ion to distort an electron cloud (as on the adjacent anion). Because the ion is small and highly charged it exhibits strong polarising powers much more so than the sodium ion which is larger and not so highly charged.

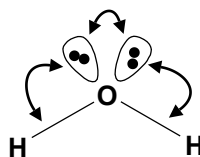
As a result of the highly polarising power of the aluminium ion the compound aluminium chloride is not typically ionic. The aluminium ion attracts electronic charge from the adjacent chloride ions introducing a high degree of covalent bonding giving the compound covalent properties.

5. It is the enthalpy change when one electron is removed from each of 1 mole of gaseous atoms of an element.

6.  $\text{Mg}^{2+}$  nuclei are embedded in a *sea of electrons* (ie, the outer electrons from the magnesium atoms). The magnesium nuclei are packed closely together and arranged systematically in layers.

7. *van der Waal* - these are weak temporary dipole-dipole or dispersion forces. They are the result of electron oscillations in the large iodine molecules.

8. The lone pairs on the oxygen occupy their own space and repel one another & the bonding pairs.



This results in an angled molecule rather than a linear molecule.

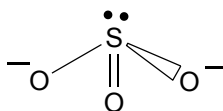
9.  $\text{H}_2\text{SO}_4$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{AgNO}_3$ ,  $\text{BaCl}_2$

10. If an aqueous solution contains sulphate ion it will precipitate barium sulphate (white solid) when treated with dilute barium chloride solution and excess dilute hydrochloric acid.



## Test 8 (Answers): Theme: Bonding, Redox.

1.



pyramidal

2. Oxidation is the removal of electrons.  $M^+ \rightarrow M^{++} + e^-$

3. Ionic, iron is being oxidised since it is losing electrons, chlorine is being reduced since it is gaining electrons.

4. (i) +7, (ii) -4, (iii) +3

5.  $\text{OCl}^-$  (-2, +1),  $\text{Cl}^-$  (-1),  $\text{ClO}_3^-$  (+5, -2).

This is a redox reaction, some chlorine is oxidised and some is reduced. It is an example of a disproportionation reaction.

6. (i) there is an increase in atomic radii down the groups.

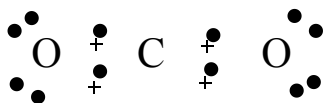
(ii) there is a decrease in ionisation energy down the groups.

(iii) the thermal stability of the nitrates decrease from group I to group II.

7. The magnesium nuclei are doubly positively charged whereas the sodium nuclei are singly charged. As a result of this the attractive forces between the metal ions and mobile electrons are stronger in magnesium than in sodium. As a result, it is harder to melt magnesium than it is to melt sodium (ie, magnesium has the higher *melting point*). Also the packing arrangement in sodium (bcc) is looser than in magnesium corresponding with sodium being less dense and softer (& more easily deformed) than magnesium.

8. K = lilac, Cu = green, Ca = brisk red.

9.



10. (a) +1, (b) -2, (c) -1 (d) +1

## Test 9 (Answers): Theme: Periodic Table.

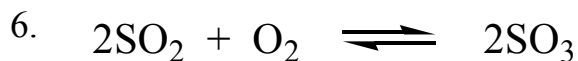
1. Lots of heat is generated when combustible material of reacted with oxygen. The heat is sufficient to initiate and sustain the burning of the flammable materials.
2. Relights a glowing splint.
3. Pale green.
4. To poison the troops.
5. Hydrogen is highly flammable, helium is inflammable.
6. Non metal.
7. Aluminium.
8. Metal.
9. Tungsten (W).
10. Russian.
11. Inorganic chemistry and Periodicity.
12. Groups.
13. Very similar chemical properties.
14. Density.
15. Alkali metals.
16. Soft.
17. Store under oil (out of contact with air).
18. Caesium (Cs).
19.  $2\text{Na} + 2\text{H}_2\text{O} \longrightarrow 2\text{NaOH} + \text{H}_2$
20. Lilac.
21. 4.
22. 3 or 5 (not 7).
23. Reacts vigorously forming a white powder ( $\text{Al}_2\text{O}_3$ ).
24.  $\text{P}_2\text{O}_5$  (ie. phosphorus(V) oxide).
25.  $\text{Cl}_2\text{O}_7$ .
26. Silvery, metallic appearance.
27. Graphite and diamond.
28. No (although they are very stable!)
29. Yes (when heated and plunged into liquid oxygen).
30. Solid/gas.
31. Because both form dioxides)
32. Sodium.
33. No.
34. Left.
35. Middle section.

## Test 10 (Answers): Halogens

1. Become less reactive.
2. Become larger.
3. Attraction become less because the shells are filling up and the outer electrons are further and further away from the nucleus. Also there is an increased shielding effect caused by the inner electrons so reducing the attraction of the nucleus for the outer electrons.
4. Fluorine, chlorine, bromine, iodine.
5. Colour change from colourless to red-brown due to displacement (liberation) of bromine by chlorine.
6. Colourless to brown as the bromine displaces (liberates) iodine.
7. Chlorine > bromine > iodine. Chlorine has greatest affinity for electrons.
8. Precipitation of a cream coloured solid (silver bromide, AgBr).
9. Atom undergoes both oxidation and reduction. eg, 
$$\begin{array}{ccccccc} \text{Cl}_2 & + & \text{H}_2\text{O} & \rightleftharpoons & \text{HOCl} & + & \text{HCl} \\ 0 & & & & +1 & & -1 \end{array}$$
10. Astatine (At).

### Test 11 (Answers): Sulphuric acid.

1. Sulphur (S).
2. (i ) compressor, (ii) drier, (iii) furnace, (iv) converter, (v) absorbers.
3. Blue.
4. Sulphur dioxide.
5. Vanadium(V) oxide.



7. Exothermic.

8. 450 °C

9. 98% sulphuric acid.

10. A heavy acid mist is formed.

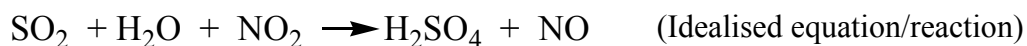


11. About 30 tons.

12. Fertilizers, paints, plastics, detergents.

13. Concentrated sulphuric acid with added sulphur trioxide (a very potent acidic mix!).

14. The lead-chamber process.



15. 1300 (Geber).

## Test 12 (Answers): General chemistry.

1. Cs, Na, Li, Ca, Mg, Be (beryllium is relatively unreactive due to the small size of its atoms and ions - forms covalent compounds).
2. K: lilac, Ca: brick red, Ba: apple green.
3. Alkali metals: 0, +1 , Alkaline earth metals: 0, +2.
4.  $\text{Na}_2\text{O}_2$  (peroxide),  $\text{Li}_2\text{O}$ ,  $\text{KO}_2$  (superoxide),  $\text{CaO}$ .  
$$\text{Na}_2\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2\text{O}_2$$
5. Sulphates: decrease (become less soluble)  
Hydroxides: increase (become more soluble)
6. Chlorine: gas, bromine: liquid, iodine: solid.
7. 
$$2\text{Cl}_2 + 2\text{Fe} \rightarrow 2\text{FeCl}_3$$
8.  $\text{Cl}_2$ : 0,  $\text{HOCl}$ : +1,  $\text{HCl}$ : -1

In a reaction, an atom of an element is both oxidised and reduced.

Bleaches damp litmus.

### Test 13 (Answers): Organic chemistry 1

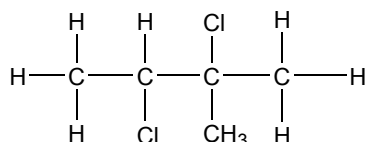
1. A family of organic compounds having the same general formula and similar chemical properties.

(or, A family of organic compounds whose molecules contain the same functional group(s) and therefore have similar chemical properties)

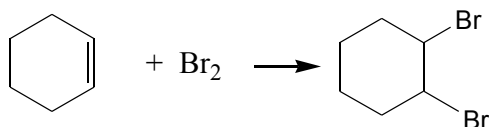
2.



3.



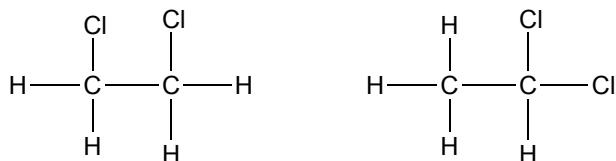
4.



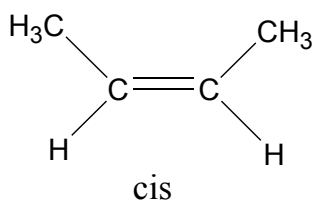
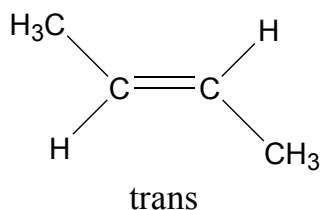
5. Purple solution converted to brown solid & colourless solution.

Unsaturation: the molecule contains one or more carbon-carbon double bonds; the doubly bonded carbon atoms do not have their full quota of hydrogen.

6.



7.

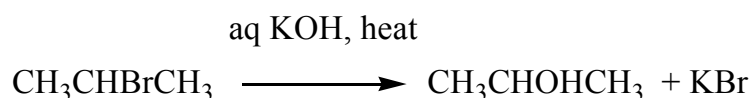


But-2-enes

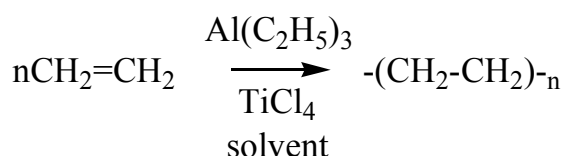
8.



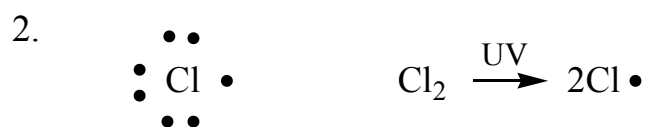
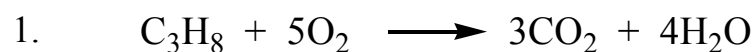
9.



10.



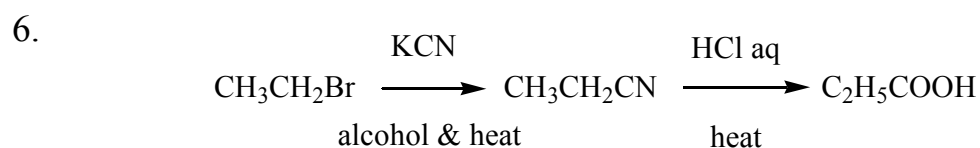
## Test 14 (answers): Organic chemistry.



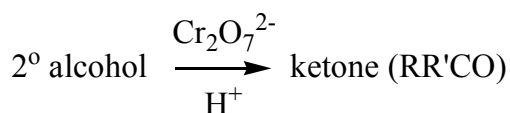
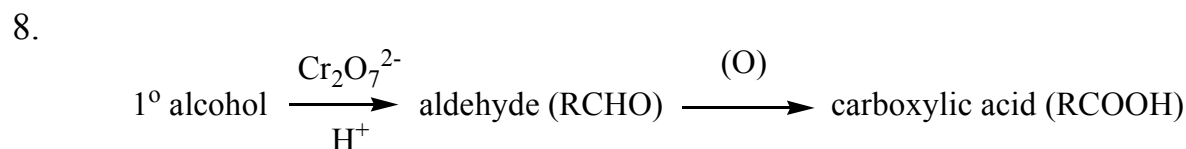
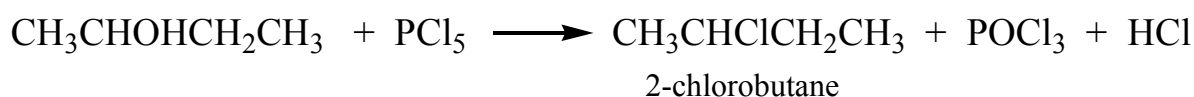
3. electrophilic addition reactions

4. Manufacture of margarine

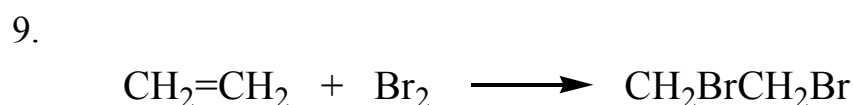
5. Ridged carbon-carbon double bond system with different groups attached to the unsaturated carbon atoms.



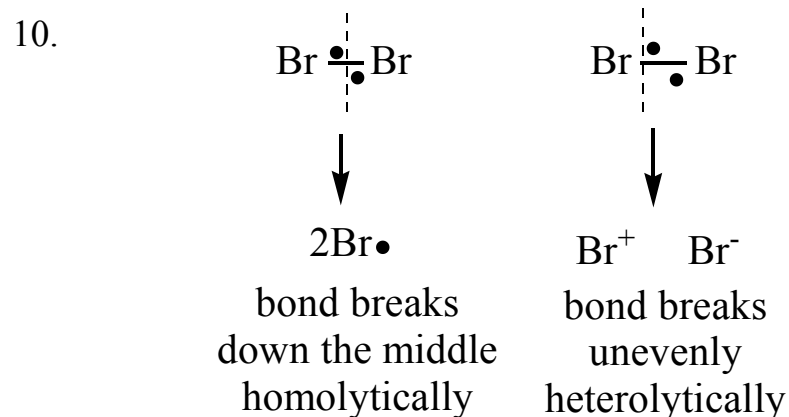
7.  $\text{CH}_3\text{CHOHCH}_2\text{CH}_3$  secondary alcohol



eg, the primary alcohol ethanol gives ethanal and ethanoic acid on oxidation.  
the secondary alcohol butan-2-ol gives butanone on oxidation.

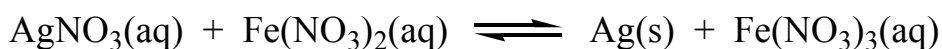


the product is 1,2-dibromoethane and the electrophile is  $\text{Br}^+$

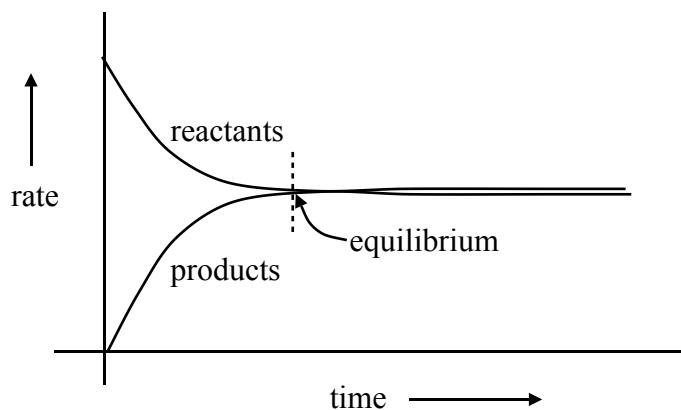


## Test 15 (answers): Chemical equilibrium.

1. It means that reactions can proceed in both the forward and reverse directions. Altering the conditions of the reaction can change the direction of the reaction.
2. Many familiar inorganic reactions like the reaction of hydrochloric acid with sodium hydroxide are not reversible. Similarly, the reaction of silver nitrate solution with sodium chloride solution is a reaction which only goes one way (ie, left to right). This produces a white precipitate of silver chloride and providing the reactants are mixed in equimolar amounts all of the silver ions and chloride ions are used up and converted to insoluble silver chloride.
3. The reaction of nitrogen with hydrogen to give ammonia is reversible. The ammonia has a tendency to decompose back into nitrogen and hydrogen particularly at elevated temperatures. The formation of sulphur trioxide from sulphur dioxide and oxygen is reversible.
4. The term dynamic equilibrium refers to a reversible reaction which has achieved equilibrium when the forward and reverse reactions occur at the same rate. The concentrations of the various reactants are then constant.
5. It suggests that there has been a good conversion of reactants to products. The final reaction mixture still contains both reactants and products but there is a greater concentration of products than reactants.
6. Double arrows are preferable to emphasise the reversible nature of the reaction.



7.



8. Le Chatelier's principle: If a constraint is applied to a reaction at equilibrium the reaction will adjust in such a way as to reduce the effect of the constraint.  
eg; If external pressure is applied to the Haber process at equilibrium the equilibrium will shift to the right since this will reduce the pressure experienced by the reacting system. In this case a shift to the right increases the yield of ammonia since the formation of ammonia reduces the overall number of moles, and hence the overall pressure, on the system.



## Test 16 (answers): Thermochemistry.

1. Exothermic: heat evolved - lost from the reacting system. eg, burning of magnesium ( or burning of fossil fuels)

Endothermic: heat absorbed - used by the reacting system. eg, photosynthesis.

2. Standard enthalpy of formation: the enthalpy change when 1 mole of a substance is made from its elements in their standard states at 1 atmosphere pressure and 298 K.

These values can be used to calculate heats of reaction.

3.

$$\Delta H_c = \sum \Delta H_{f, \text{products}} - \sum \Delta H_{f, \text{reactants}}$$
$$= -393 + (2 \times -286) - (-239)$$

$$= -393 + (-572) + 239 = -726 \text{ kJmol}^{-1}$$

4. Hess's law: the enthalpy change for a given reaction is independent of the route by which the reaction is achieved, provided that the temperatures, pressures and physical states of the reactants and products are the same in each case.

5.

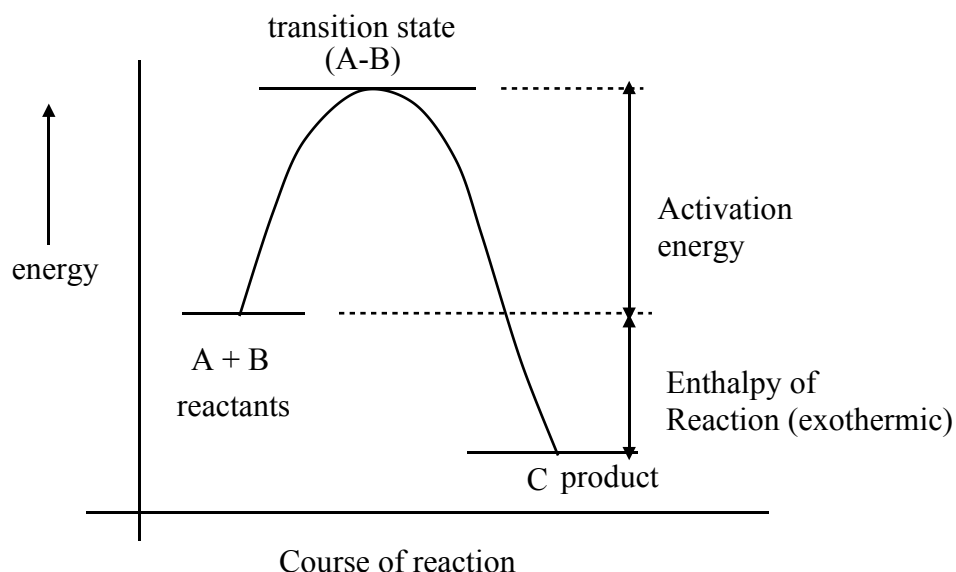
$$-370 \text{ kJmol}^{-1} = [2 E(\text{C} \equiv \text{O}) + 496] - [ (4 \times 743) ]$$
$$E(\text{C} \equiv \text{O}) = 0.5 [ -370 - 496 + 2972 ] = +1053 \text{ kJmol}^{-1}$$

6. F-F, H-H, N≡N, HF hydrogen fluoride

7. This is the heat required to raise the temperature of 1g of water 1° K

## Test 17 (answers): Thermochemistry & Organic chemistry

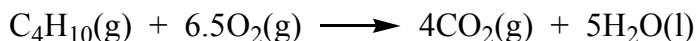
1.



### Test 17 (answers):

2. (i) The heat change on complete combustion, in excess oxygen, of one mole of butane under standard conditions.

(ii).



(iii). Relative molecular mass of butane = 58.

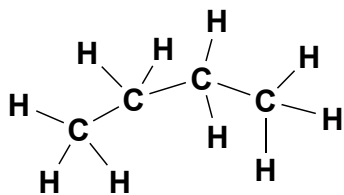
$$\text{Moles in cylinder} = 2500/58 = 43.10$$

(iv).  $43.10 \times 2877 = 124 \text{ kJ}$  (exothermic)

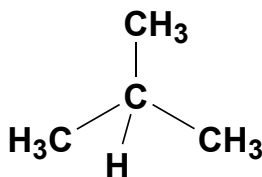
(v). (i) large heat loss to surroundings

(ii) incomplete combustion

3.



butane



2-methylpropane

### Test 18 (answers): Chemistry kinetics.

1. The amount of reactant which undergoes reaction in unit time (eg, per second or per minute) or the amount of product formed in unit time.

2. (i) increase in temperature, (ii) increase in concentration, (iii) physical state, ie, more finely divided, (iv) positive catalyst.

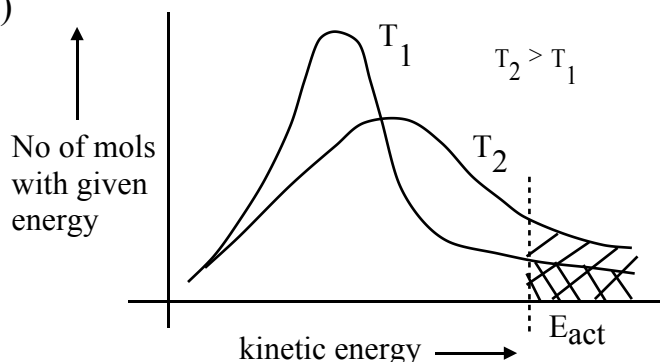
3. (i) Initially the acid is more concentrated and therefore more collisions per unit time and more rapid reaction. The magnesium has a higher surface area at the beginning and therefore faster rate.

(ii) about 60 seconds (when the graph levels off).

(iii) Surface area is doubled and therefore the rate doubles but since there is twice as much magnesium to react the reaction takes the same length of time to complete.

(iv) The only change would be in the rate of reaction. The catalyst would provide a less energetic route which means that, at a given temperature, the reaction would be quicker and be completed in less time.

(v)



At the higher temperature more of the reactant molecules have the required energy of activation therefore there are more successful collisions.  
(the larger the shaded area under the curves the more molecules have the required activation energy)

## Test 19 (answers): Some Industrial inorganic chemistry.

1. Haber process:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$

A catalyst of iron and aluminium oxides, a temperature of about  $350^\circ\text{C}$  and a pressure of about 350 atmospheres.

Higher pressure and lower temperature would favour the left to right reaction. However, a higher pressure would make the process less economic due to the increased costs of equipment and maintenance and a lower temperature would slow the reaction again reducing the overall economy.

2. Nitric acid the, Ostwald process: Ammonia is oxidised in air using a catalyst of rhodium and platinum at a temperature of about  $800^\circ\text{C}$  and 5 atmospheres pressure. Nitrogen(II) oxide is formed which is oxidised in air over a countercurrent of water to give a 60% solution of nitric acid. Distillation and treatment with a suitable dehydrating agent provides 98% nitric acid.

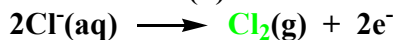
Large amounts of nitric acid are used in the manufacture of fertilizers, explosives dyestuffs and nylon.

3. Chlorine is made on a large scale by the electrolysis of brine. The membrane (or, diaphragm) cell is a modern, relatively environmentally friendly process. Brine is electrolysed between carbon electrodes. The membrane divides the anode and cathode compartments so reducing the possibility of chlorine mixing with sodium hydroxide (a product of the process). Chlorine is formed at the anode and hydrogen gas and sodium hydroxide solution are formed at the cathode.

At the cathode (-):



At the anode (+):



Sodium chlorate(I) is formed by electrolysing cold brine so that the chlorine gas is allowed to mix with the sodium hydroxide solution. The two react to give a solution of sodium chloride and sodium chlorate(I).



4. **Uses of Chlorine:** (About 11 million tonnes /yr in Europe)

Large amounts used to sterilise domestic water supplies including water for swimming pools.

For bleaching wood pulp used in paper manufacture.

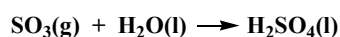
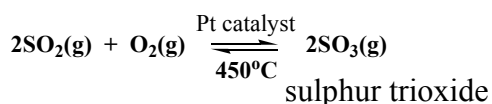
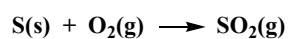
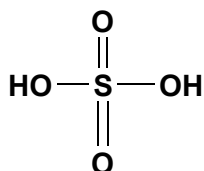
For making chloroethene which is the raw material for the manufacture of polyvinyl chloride (PVC).

For making other organic chemicals which, in turn, are used to make drugs, insecticides, solvents and refrigerants.

For making hydrogen chloride which is combined with water to give hydrochloric acid.

For making sodium chlorate(I). This chemical is the principle constituent of bleach.

5.



1. Fertilizers (33%).
2. Paints and pigments (17%).
3. Chemicals (16%).
4. Detergents (10%).
5. Pickling, oil refining & anodising. (about 20%).
6. Other uses.

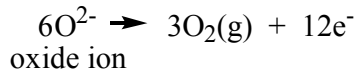
## Test 20 (answers): Aluminium & Iron.

1. 8%, bauxite,  $\text{Al}_2\text{O}_3$ ,

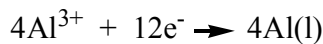
(i) graphite, (ii) alumina, cryolite, aluminium fluoride, (iii)  $900^\circ\text{C}$

(iv), (v)

At the Anode:



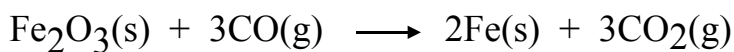
At the Cathode:



In order for the manufacture of aluminium to be economic, a cheap source of electric power must be available (eg, as provided by hydroelectric power stations).

2. Iron(II) and iron(III), green  $\text{Fe}(\text{II})(\text{aq})$ , yellow  $\text{Fe}(\text{III})(\text{aq})$  and reddish-brown as in  $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ,  $[\text{Fe}(\text{CN})_6]^{4-}(\text{aq})$  (hexacyanoiron(II) or ferrocyanide) this forms pale yellow crystals as the potassium salt. Iron(III) also forms a complex with cyanide which gives orange-red crystals as the potassium salt.

*Haematite* is an important ore of iron. This contains  $\text{Fe}_2\text{O}_3$



Reducing agent: carbon monoxide. This is produced from the reduction of carbon dioxide and the oxidation of carbon (from coke).

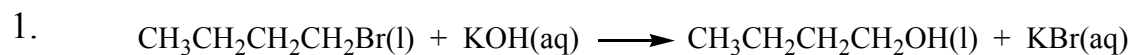
Slag: calcium silicate.

Tuyeres: tubes or pipes delivering hot air to the charge near the base of the furnace.

Pig iron (also known as *cast iron*; it contains carbon and many metallic impurities (in total, amounting to about 5%), it is brittle).

Large quantities of iron are used to make steels which are used in manufacturing and construction industries.

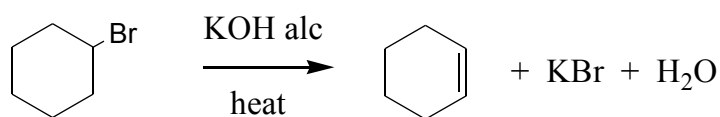
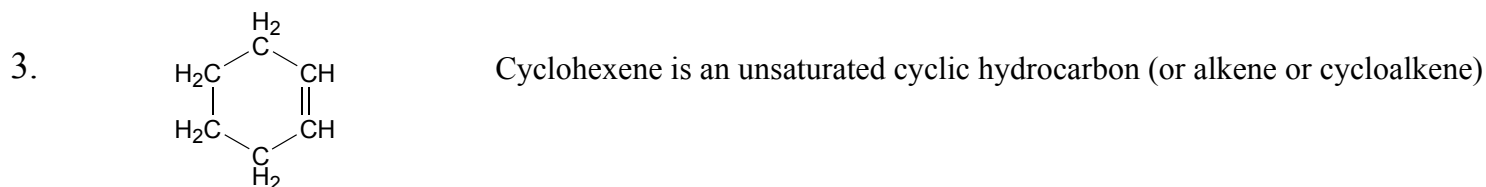
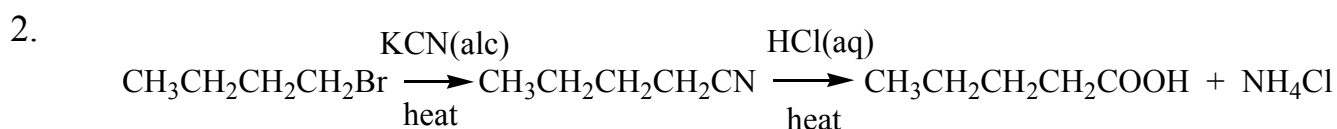
## Test 21 (answers): More Organic chemistry.



The hydroxide ion:  $\text{H}\ddot{\text{O}}^-:$

Rate could be increased by, raising the reaction temperature and/or increasing the miscibility of the reaction mixture by using potassium hydroxide dissolved in a mixture of alcohol and water rather than water alone.

When warmed with silver nitrate solution haloalkanes are slowly hydrolysed and the liberated halide ion forms a precipitate of silver halide (AgCl - grey-white, AgBr - cream, AgI - yellow).



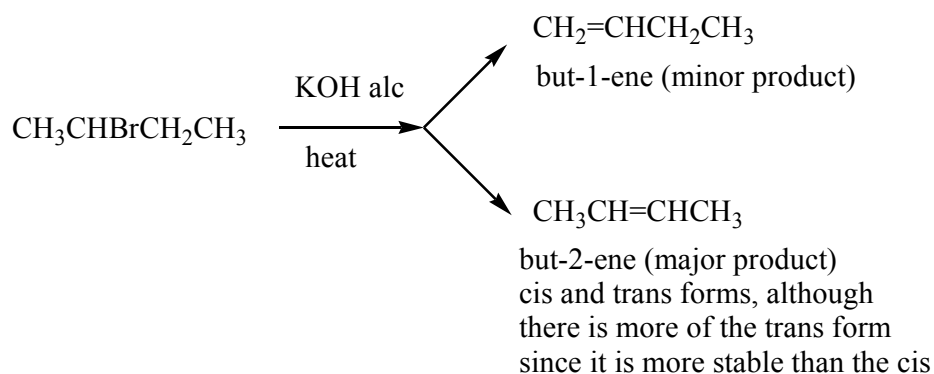
Attempted removal of HBr from bromocyclohexane by refluxing with a hot solution of KOH will result in the formation of some cyclohexanol as a result of nucleophilic substitution.

An elimination reaction involves the removal of HX from a halogenated organic molecule by treatment with hot, alcoholic KOH. Hydrogen and halogen (X) atoms are removed from adjacent carbon atoms so forming a double bond between the two carbon atoms.

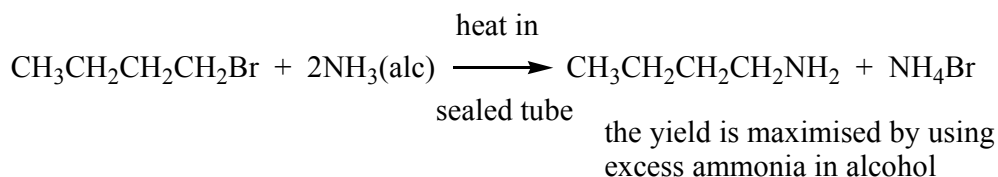
5-chlorohept-1-ene

## Test 22 (answers): More Organic chemistry.

1.



2.



3. DDT: dichlorodiphenyltrichloroethane

DDT was widely used as an insecticide (particularly to eradicate malaria the mosquito-borne disease). Due to the fact that it does not readily degrade in the environment, its use is now banned or restricted to avoid accumulation of the chemical in the food chains.

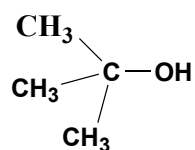
4.



butan-1-ol  
(primary)



butan-2-ol  
(secondary)

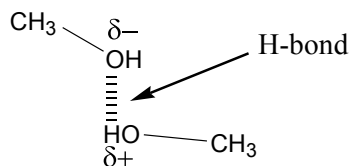


2-methylpropan-2-ol  
(tertiary)

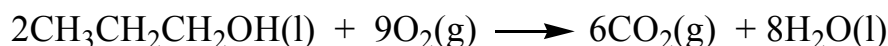
5. Methanol is an alcohol,  $\text{CH}_3\text{OH}$ .

In the liquid phase its molecules are hydrogen bonded to one another. Since this intermolecular bonding is quite strong a considerable amount of heat energy is required to separate the molecules during the boiling process.

The ethane molecules are not hydrogen bonded and have much weaker intermolecular attractive forces and therefore ethane has a lower boiling point.



6.



Since this alcohol has saturated molecules it burns with a clean flame (not sooty).

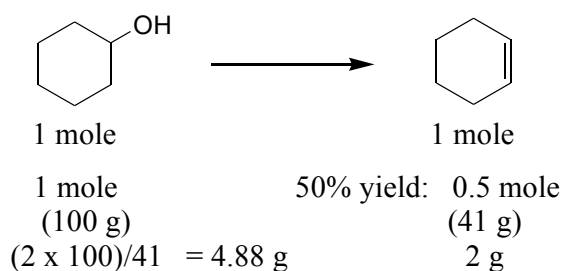
### Test 23 (answers): More Organic chemistry.

1. Both alcohols are oxidised by heating with the dichromate reagent (the oxidation is accompanied by a colour change from orange to green). However, butan-1-ol is oxidised to butanal and then to butanoic acid whereas butan-2-ol is oxidised to butanone. Butanal and butanoic acid are readily identified by their odours which are rather unpleasant and quite distinct from that of butanone.

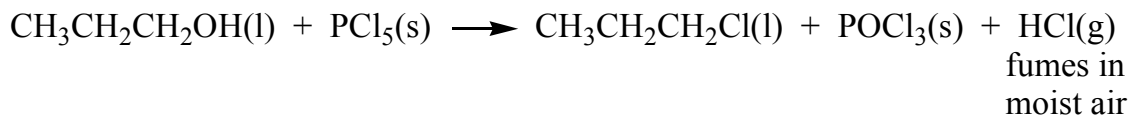
If further evidence is required the products could be isolated by distillation and their boiling points measured and compared with literature values. Also, their infra red spectra could be compared.

The ir spectrum of butanoic acid shows broad intense absorption between 2700 and 3500 wave-numbers due to the carboxyl group.

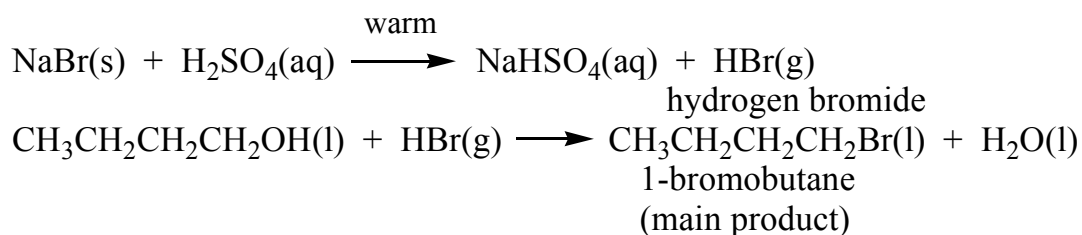
Type of reaction: *dehydration* (removal of the elements of water).



3. In a distillation flask treat propan-1-ol with phosphorus pentachloride and distil off the chloroalkane.



4.

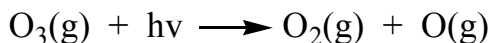


## Test 24 (answers): Some environmental chemistry.

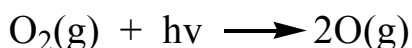
### 1. Stratosphere.

It is beneficial because it absorbs ultra violet light and helps protect us from the harmful effects of excessive amounts of this radiation.

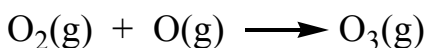
In the upper atmosphere the photodissociation of ozone produces oxygen molecules and oxygen atoms:



The photodissociation of oxygen itself gives oxygen atoms:



However, under *natural conditions*, the ozone is replenished as a result of oxygen molecules combining with oxygen atoms:



After a while a steady state is reached when the concentrations of ozone, oxygen and oxygen atoms remain constant.

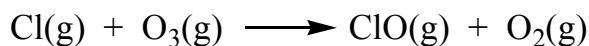
### 2. CFC's: chlorofluorocarbons.

He was looking for a refrigerant which was less toxic than those available at the time (eg, sulphur dioxide and ammonia). In dichlorodifluoromethane he found a substance which is non toxic to humans and readily liquified by application of moderate pressure.

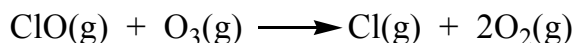
In the stratosphere molecules like dichlorodifluoromethane undergo photodissociation to give chlorine atoms:



These chlorine atoms (chlorine free radical) combine readily with ozone giving oxygen and chlorineoxide:



Furthermore, chlorineoxide also reacts with ozone giving more chlorine free radicals and oxygen:



In this way dichlorodifluoromethane quickly depletes the ozone in the stratosphere. The solution to the problem is to ban the use of CFC's as refrigerants and find alternatives which do not undergo photodissociation in the upper atmosphere resulting in ozone depletion.

3. Greenhouse effect: This is the effect that atmospheric gases have in optimising the temperature at the earth's surface. It is a natural effect; the gases act as a kind of blanket preventing too much heat escaping from the surface into the upper atmosphere thereby keeping the surface temperatures acceptable. However, when certain gases (eg, carbon dioxide and methane) are produced in excessive amounts too much heat is retained by the atmosphere and as a result the temperature at the surface rises above normal. The phenomenon is known as *global warming*. As more and more of these so called greenhouse gases are released into the atmosphere the surface temperature of the earth increases, the ice caps melt and the sea level rises resulting in flooding.

### 4.

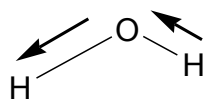
cis-hex-3-en-1-ol

3,4-dibromohexan-1-ol.

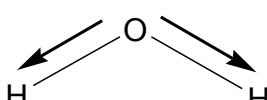


## Test 25 (answers): Infra-red spectroscopy.

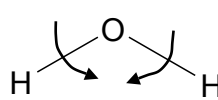
1.



unsymmetrical  
stretch



symmetrical stretch

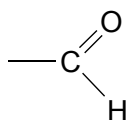


bending

2. This is an expression of the wavelength ( $\text{cm}^{-1}$ ) of ir radiation. It is the reciprocal of the wavelength, in cm, and is proportional to the energy of the radiation.

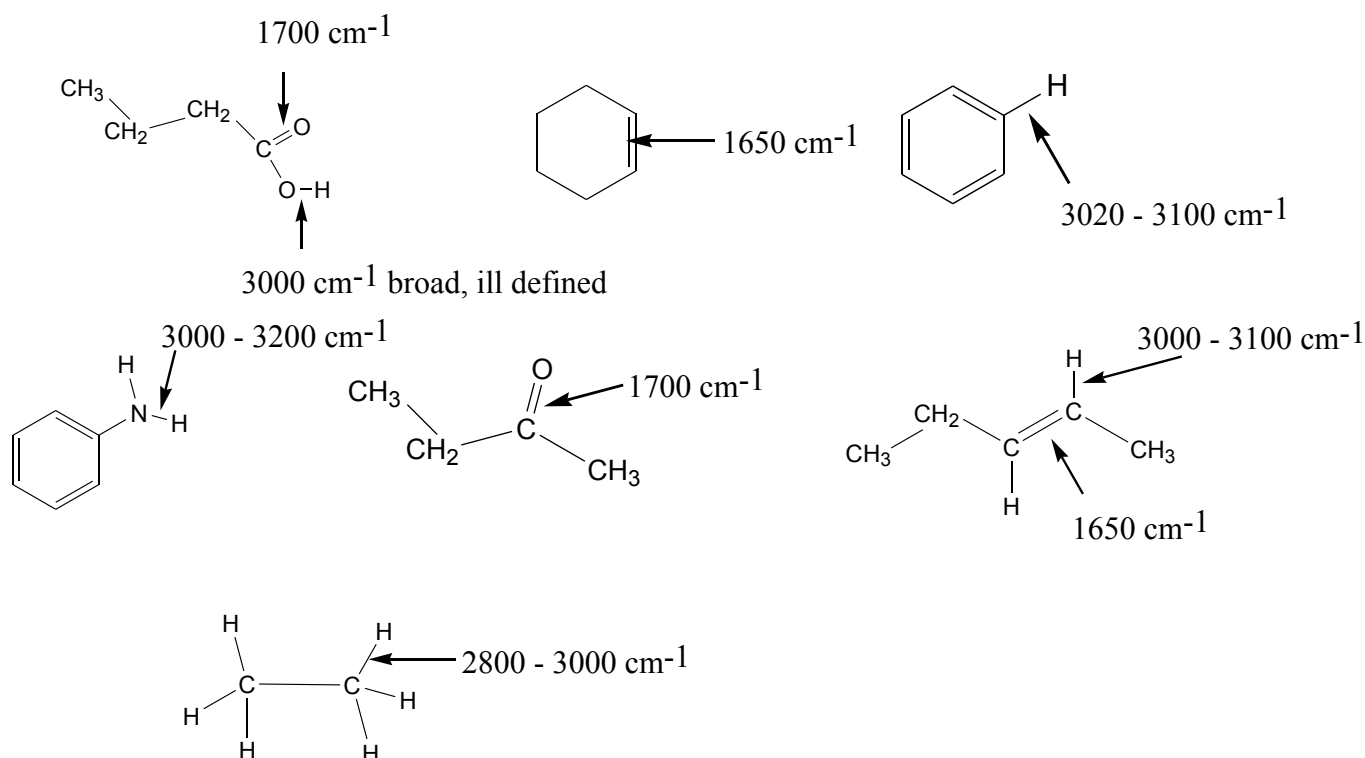
3. It is the region between about  $400$  &  $1500 \text{ cm}^{-1}$ . It is a region of the spectrum which usually has a large number of absorption peaks. The number, positions and size of peaks in this region is very characteristic of the molecular structure. It is a fingerprint of the molecule!

4. The saturated aldehyde group absorbs strongly at  $1700 \text{ cm}^{-1}$  ( $\text{C}=\text{O}$  stretch) and less strongly but sharply at  $2700 \text{ cm}^{-1}$  ( $\text{C}-\text{H}$  stretch).



5. It shows broad, intense, absorption due to the hydroxyl group in the range  $3050 - 3750 \text{ cm}^{-1}$ . Also, strong absorption  $2700 - 3000 \text{ cm}^{-1}$  due to the saturated  $\text{C}-\text{H}$  stretch (in the  $\text{CH}_2$  &  $\text{CH}_3$  groups).

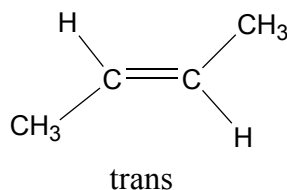
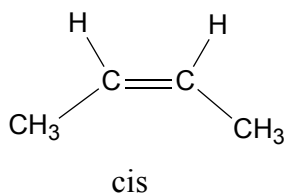
6.



butanoic acid, cyclohexene, benzene, benzenamine (aminobenzene), butanone, but-1-ene (trans), ethane.

## Test 26 (answers): Stereoisomerism.

1. But-2-ene exists in cis and trans forms.

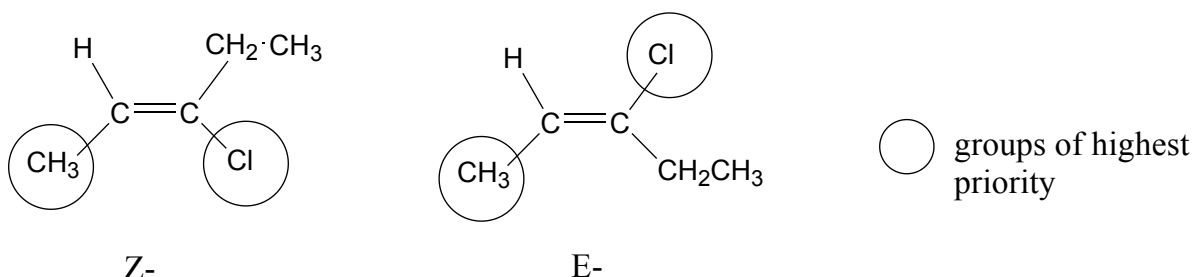


These structures correspond to distinct molecules. They are not readily interconvertible as a result of the rigidity of the carbon-carbon double bond. We say there is restricted rotation about the carbon-carbon double bond.

2.

Each of the unsaturated carbon atoms must be substituted by different groups. However, as in but-2-ene, the unsaturated carbon atoms can have common substituents (ie, H & CH<sub>3</sub>).

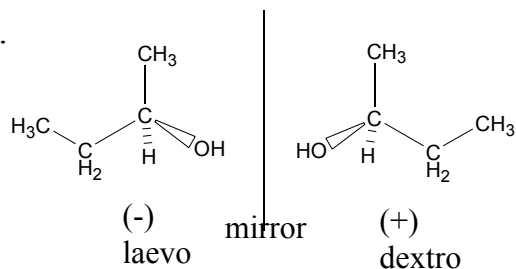
3.



4. Light vibrating in a single plane. (Ordinary light has a more complex waveform vibrating in a multitude of different planes).

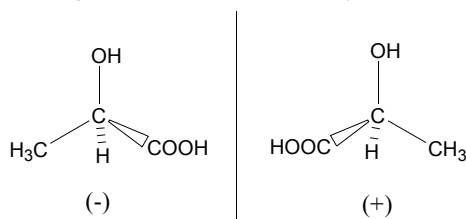
5.

Enantiomers are non-superimposable mirror images.



These molecules are asymmetric (chiral) by virtue of the chiral centre (carbon 2) which is attached to four different groups. The molecules lack a plane of symmetry with the result that the mirror image molecule is non-superimposable on the object molecule. One molecule rotates plane polarised light to the right (dextro rotatory) whilst the other rotates it to the left (laevo rotatory).

6.



7. Polarimeter.

8. A 1:1 molar mixture of enantiomers constitutes a racemic mixture. The mixture would not show optical activity because the laevo and dextro forms would rotate plane polarised light in opposite directions by equal amounts (their rotations would cancel).

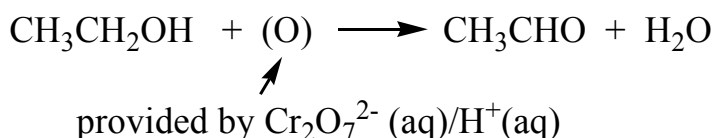
**Test 27 (answers): More Organic chemistry.**

1. Aldehyde:  $\text{RCHO}$ , Ketone:  $(\text{R})_2\text{CO}$  (the alkyl groups may be the same or different).

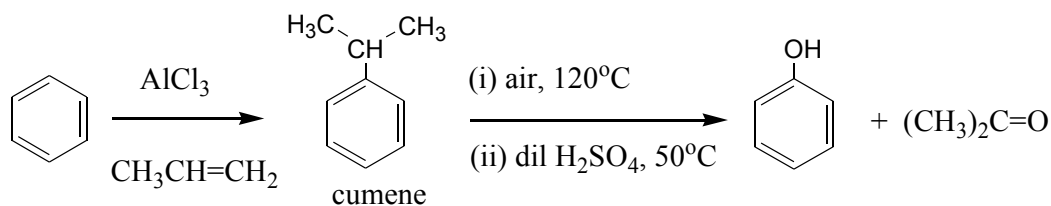
2. Introduce 2 cm<sup>3</sup> 0.1M AgNO<sub>3</sub> into a test-tube. Add a drop of 2M NaOH and then, with stirring, add 2M NH<sub>3</sub>(aq) dropwise until the grey precipitate JUST dissolves. This is Tollen's reagent. It is used to test for aldehydes. A few drops of the aldehyde reacts with Tollen's reagent forming metallic silver. This may appear as a grey precipitate but often forms a silver mirror on the inside surface of the test-tube. The test is sometimes known as the *silver mirror test*. Ketones do not give a result with this reagent.

### 3. Potassium dichromate ( $K_2Cr_2O_7$ ).

It is important to distil off the aldehyde before it has a chance to be oxidised to the corresponding carboxylic acid. Ethanal boils at about 27°C and will flash distil under the conditions stated. The procedure ensures that very little ethanal is oxidised to ethanoic acid.



4. By the *cumene process*.



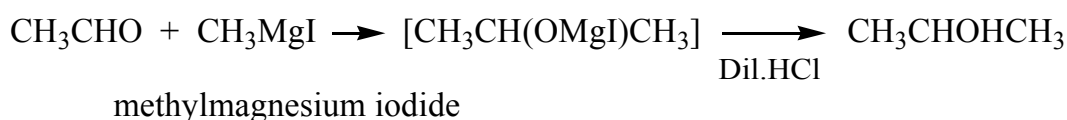
## 5. Propan-2-ol

Hydride ion ( $\text{H}^-$ )6.  $\text{CHI}_3$  (tri-iodomethane)

It is used to test for the  $\text{CH}_3\text{CO}$  group in methyl ketones. If a molecule contains this group it should react when warmed with dil. sodium hydroxide and iodine to give bright yellow iodoform crystals.

7. A solution of this reagent in methanol, acidified with a little concentrated sulphuric acid, gives a yellow or orange coloured precipitate of the corresponding hydrazone when treated with a carbonyl compound. The reaction is an example of a condensation reaction since, in addition to the hydrazone, water is produced. The acidified, methanolic, solution of 2,4-dinitrophenylhydrazine is sometimes referred to as *Brady's reagent*.

8. RMgX where X = a halogen (usually iodine or bromine).

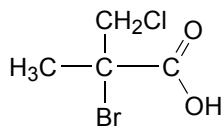
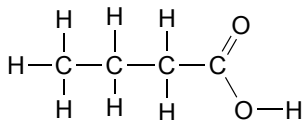


9.  $\text{CH}_3/\text{CH}_2$  - strong absorption at  $2900\text{ cm}^{-1}$ ,  $-\text{CHO}$  - medium absorption at  $2700\text{ cm}^{-1}$ , carbonyl stretch - strong absorption at  $1720\text{ cm}^{-1}$ .

The major difference would be the absence of the -CHO peak in the spectrum of hexan-2-one.

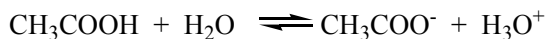
## Test 28 (answers): Carboxylic acids.

1.



It has good compatibility with water since it is a small molecule with a highly polar group which effectively hydrogen bonds with water molecules providing strong intermolecular bonding.

2. A weak acid such as ethanoic acid is only partially dissociated in water. Most of its molecules remain whole and only a few break up to give ethanoate and hydrogen ions.

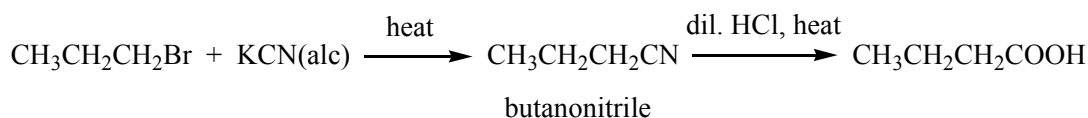
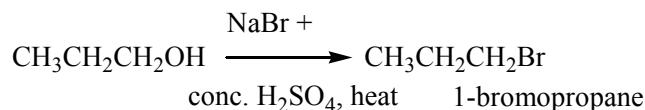
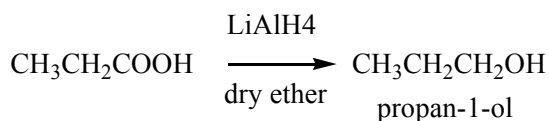


Since the concentration of hydrogen ions is low the pH is relatively high and the solution is only weakly acidic.

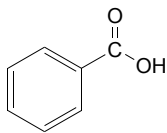
3. (1) A simple carboxylic acid will give carbon dioxide when treated with a dilute solution of sodium carbonate. Evolution of the gas gives effervescence.

(2) Carboxylic acids react with alcohols, in the presence of a little concentrated sulphuric acid, forming esters. These can usually be recognised by their pleasant odours. Ethanoic acid, for example, reacts with ethanol giving ethyl ethanoate which has a fruity odour.

4. Eg,

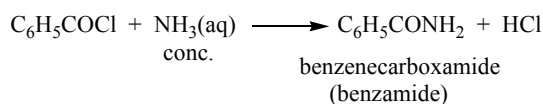
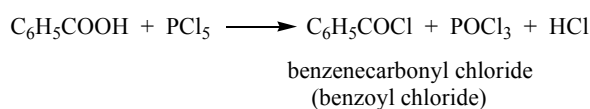


5.



Introduce a small plug of the acid into a capillary tube sealed at one end. Place the sealed tube, sealed end first, into the heating block of the electric melting point apparatus. Slowly raise the temperature of the block until you observe the crystals melt (turn to liquid). Record the melting temperature shown on the thermometer.

The acid *reacts* with the alkali giving a soluble sodium salt.

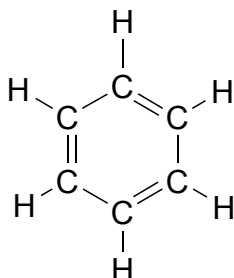


benzoate ion

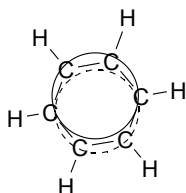
## Test 29 (answers: Carboxylic acids, Aromatics & Transesterification).

1. They are indicative of the carboxylic acid group (-COOH). The intermolecular hydrogen bonded hydroxyl group in the COOH group, gives a characteristically intense and broad absorption centred around  $3100\text{ cm}^{-1}$ . The carbonyl component of the COOH group show stretching at about  $1700\text{ cm}^{-1}$ .
2. 3,7-dimethylocta-2,6-dienoic acid (nerolic acid).  
It is produced by bees.

3.



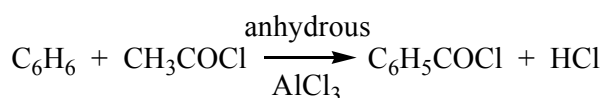
Since the molecule is cyclic the pi electrons conjugate and occupy an annular molecular orbital so that the electron cloud is spread out (delocalised) above and below the six carbon atom ring.



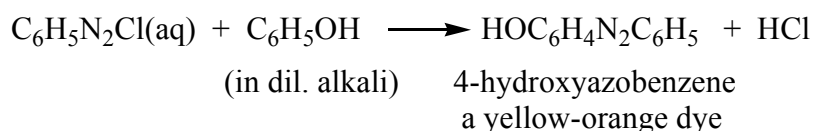
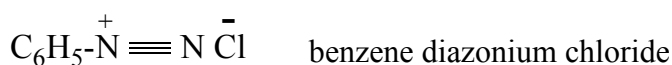
This is a particularly stable arrangement and accounts for the chemical stability of the molecule. Some aliphatic trienes exhibit pi electron conjugation and form *linear* delocalised electron systems. However, they are unable to form annular rings of delocalised electrons and are therefore not as stable as benzene and other arene structures.

Electrophilic substitution (rather than addition)

4.



5.



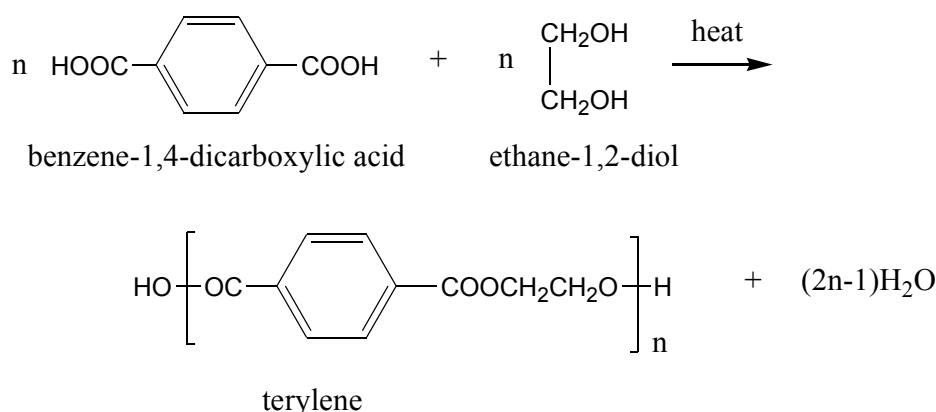
6.

Biodiesel is often a mixture of methyl or ethyl esters of fatty acids. These esters are high molecular mass, derived from the saponification of animal and vegetable fats in aqueous ethanolic or methanolic solution.

The original fats are mixtures of *glyceride esters* and they are converted, in the saponification process, into *methyl or ethyl esters*.

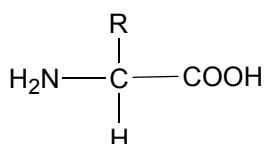
### Test 30 (answers): Terylene, Proteins & Amino acids.

1. It is a reaction in which a macromolecule is built up from smaller molecules and in the process water (or some other small molecule) is formed in addition to the macromolecule.



2. Molecules of carbohydrates contain the elements, carbon, hydrogen and oxygen. The simpler ones are mostly saturated polyhydroxy aldehydes. Protein molecules contain the elements, carbon, hydrogen, oxygen, nitrogen and often sulphur. They are polyamides and their molecules often contain phenyl groups as a result of phenylalanine and tyrosine components.

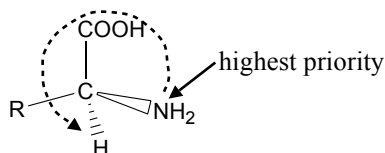
3.



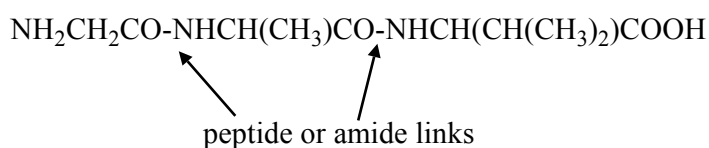
where R = aliphatic or aromatic group

they are the building blocks of proteins

4.



5.



In this example alanine is in the middle.

They could be linked together with glycine or valine forming the central link.

6.  $\alpha$ -amino acids are amphoteric behaving as both acid and base. Furthermore, the amine group can accept a proton from the carboxylic acid group so that the molecule has positive and negative ends (ie, dipolar), eg, glycine  $\text{NH}_3^+\text{CH}_2\text{CO}_2^-$ . This dipolar nature accounts for the crystallinity, water solubility

and relatively high melting points of these amino acids.

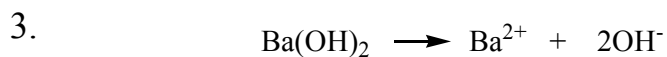
7. Chromatography is used. In its simplest form this involves spotting the amino acid mixture onto chromatography paper along side amino acid standards (ie, solutions of authentic, known, amino acids) and eluting the paper with a suitable solvent. As the amino acid mixture moves through the paper medium, the amino acids separate according to their affinity for the paper and their solubility in the eluting solvent. The individual unknown amino acids can be identified by comparing  $R_f$  values and colours of the located spots with those of the standards.

### Test 31 (answers): Theme: Acid-base Equilibria.

1.  $\text{pH} = -\log[\text{H}^+]$  (this is the so called, 'calculated' pH as opposed to the 'measured' pH)

2. 
$$1 \times 10^{-4} = \frac{[\text{H}^+][\text{In}^-]}{[\text{HIn}]} = [\text{H}^+]$$

$$-\log [\text{H}^+] = -\log 1 \times 10^{-4} = 4$$

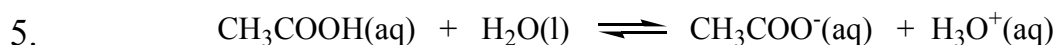


$$[\text{OH}^-] = 2 \times 0.02 = 0.04$$

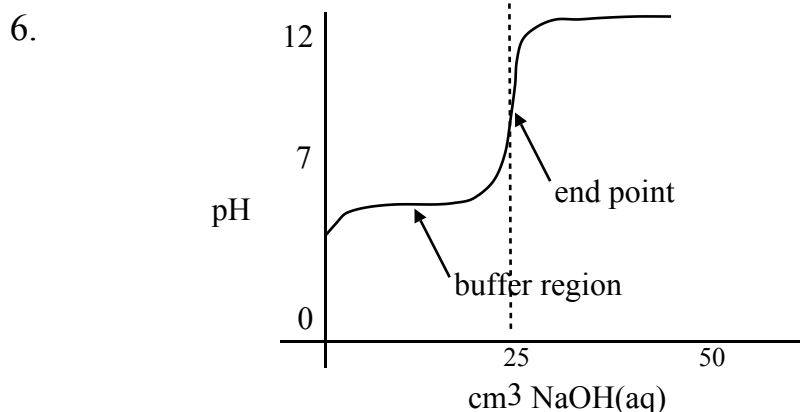
$$[\text{H}^+] = \frac{10^{-14}}{0.04} = 2.5 \times 10^{-13}$$

$$\text{pH} = -\log [\text{H}^+] = -\log 2.5 \times 10^{-13} = 12.6$$

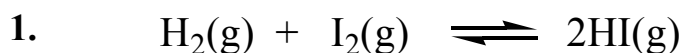
4.  $\text{pH} = -\log [\text{H}^+] = -\log 0.05 = 1.30$



When hydrochloric acid is added the extra hydrogen ions are mopped up by ethanoate ions largely provided by the sodium ethanoate. When sodium hydroxide is added the extra hydroxide ions are mopped up by hydrogen ions provided by dissociation of ethanoic acid. In both cases the net result is just a small change in pH.



Buffer region: about half way in the titration when  $[\text{CH}_3\text{COO}^-] = [\text{CH}_3\text{COOH}]$  and the buffer action is most pronounced (ie, small changes in pH even though alkali continues to be added).

**Test 32 (answers): Theme: Chemical Equilibria.**

$$K_c = \frac{[\text{HI}]^2}{[\text{H}_2] [\text{I}_2]}$$

$$K_c = \frac{0.8^2}{0.1 \times 0.1} = 64$$

No units. Because there are the same number of concentration terms in the top line as in the bottom line of the expression for  $K_c$ . Therefore the units cancel.

2. (i) (mole of reactant / total number of moles of reactants), ie, the fraction of all the moles which are moles of that particular reactant. (ii)  $p = \text{mole fraction} \times P_T$

3. 
$$K_p = \frac{(p\text{NO}_2)^2}{(p\text{N}_2\text{O}_4)}$$

$$2000 = \frac{200^2}{(p\text{N}_2\text{O}_4)}$$

$$(p\text{N}_2\text{O}_4) = \frac{200^2}{2000} = 20 \text{ kPa}$$

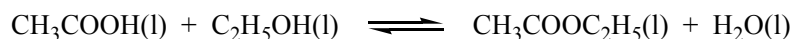
$$P_T = 200 + 20 = 220 \text{ kPa}$$

4.

Homogeneous - all reactants in the same phase, eg,  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$

Heterogeneous - not all of the reactants in the same phase, eg,  $\text{Cu}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightleftharpoons \text{Cu}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$

5.



$$K_c = \frac{[\text{CH}_3\text{COOC}_2\text{H}_5] [\text{H}_2\text{O}]}{[\text{CH}_3\text{COOH}] [\text{C}_2\text{H}_5\text{OH}]} = 4$$

$$= \frac{X^2}{2 \times 3.5}$$

$$X = (4 \times 2 \times 3.5)^{1/2} = 5.29 \text{ mol dm}^{-3}$$

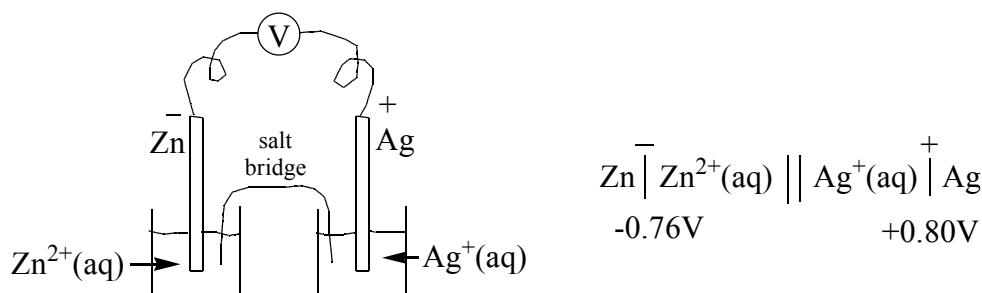
( = concentrations of ester and water)



### Test 33 (Answers): Theme: Redox Equilibria.

1.

(a)

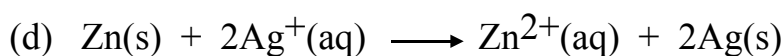


(b)

$$E_{\text{cell}} = \text{right} - \text{left} = 0.80 - (-0.76) = 1.56\text{V}$$

(c) 1. The solution concentrations may not be standard 1M.

2. The pressure may not be standard 1 atmosphere (101 kPa)



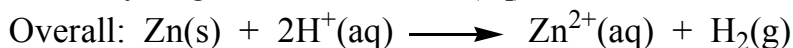
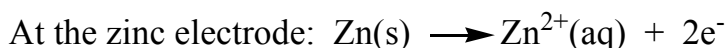
2. (a) In order for the reaction to go from left to right iron must reduce nickel. The standard electrode potentials indicate that it is possible since the iron potential is more negative than that of the nickel electrode (ie, the iron system is the more powerful reducing system).

(b) In this case mercury must reduce iodine. This is not possible since mercury is the weaker reducing system.

3. A primary cell is a battery which deteriorates with use and cannot be recharged. A secondary cell loses its charge with use but can be recharged.

4. A fuel cell is an electrochemical device which produces electric power by reacting a reductant such as hydrogen with an oxidant such as oxygen, in such a way as to provide electron transfer via an external circuit. Reductant and oxidant are provided, to the fuel cell, from external stores. The cell will provide an electric current just so long as these supplies are maintained.

5. The negative sign indicates that the electrode carries a negative charge and has the capacity to provide electrons. Electrons would flow from the zinc electrode to the hydrogen electrode.



### Test 34 (answers): Theme: Industrial Chemistry.

1.  $\text{H}_2\text{SO}_3$  (sulphuric(IV) acid),  $\text{H}_2\text{SO}_4$  (sulphuric(VI) acid).

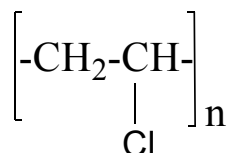
2. This refers to a process in which dilute sulphuric acid is used to clean iron (eg, removal of rust from the sheet metal).

3. This is a mixture of calcium sulphate and calcium dihydrogen phosphate (it is made by treating calcium phosphate with sulphuric acid).

4. An aqueous solution of sodium chloride.

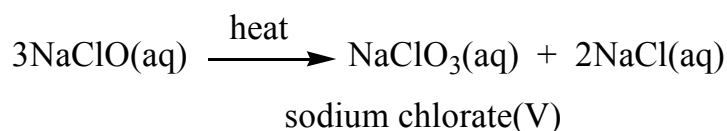
Cathode:  $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$

Anode:  $2\text{Cl}^-(\text{aq}) \longrightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$



(addition reaction):  $\text{CH}_2=\text{CH}_2 + \text{Cl}_2 \longrightarrow \text{CH}_2\text{ClCH}_2\text{Cl}$

5.

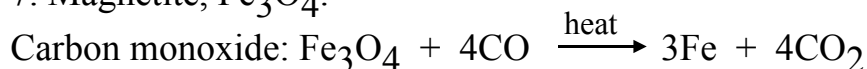


Sodium chlorate(V) is manufactured by electrolysis of brine at about  $75^\circ\text{C}$  allowing the chlorine to mix and react with the sodium hydroxide.

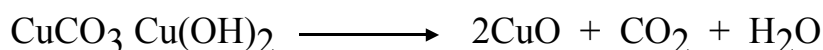
6. Bauxite.

Various alloys (eg, duralumin, magnalium) for cars, aircraft and ships, cooking utensils, aluminium door and window frames, insulation blankets, mirrors for telescopes.

7. Magnetite,  $\text{Fe}_3\text{O}_4$ .

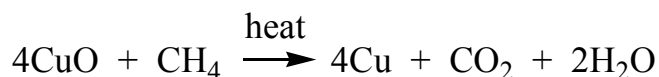


8.  $\text{CuCO}_3$   $\text{Cu}(\text{OH})_2$ , green

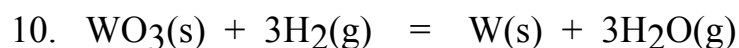


Reduce the oxide by heating in a stream of hydrogen or methane.

Eg,



9. Tungsten



### Test 35 (answers): Theme: Organic Analysis.

1. Melting points and boiling points are criterion of purity. These are measurements which are used to confirm the identity and purity of a substance. If the measurement agrees with the accepted literature value it is confirmation that the given sample is a pure example of the named substance.
2. Paper chromatography of inks and food colourings provide good examples. Employing suitable solvents (mobile phase) mixtures of these dyes can be separated to give individual coloured lines or spots on a chromatogram. The colour and position of the spots is characteristic of the individual dye.
3. This property locates a separated component on the chromatogram relative to the origin, ie,  $R_f \text{ value} = \frac{\text{distance travelled by component from the origin}}{\text{distance travelled by the solvent front from the origin}}$ .
4. Paper chromatography uses chromatography paper (eg, Whatman No 1) as the support and stationary phase. Tlc usually employs silica gel coated on an inert plastic or glass support.
5. As a general rule column chromatography would be used. Large chromatography columns can easily accommodate a gram or more of mixture. Ordinary tlc plates can only take fractions of a gram due to the thinness of the silica gel film.
6. HPLC - high performance liquid chromatography. The stationary phase is packed into robust steel tubes and the mobile phase is pumped through the tubes at high pressure. The method usually gives rapid and reproducible results and can be used to separate mixtures of polar constituents (eg, acids and bases).
7. In this chromatographic procedure a gas is used as the mobile phase carrying the vapourised mixture through a heated glass or metal chromatography column. The columns vary in diameter from about 5 mm to fractions of a mm (ie, capillary columns). They also vary in length, 50 m is not uncommon. The columns can be packed with siliceous material or coated on the insides with an involatile semi solid stationary phase (eg, high molecular mass hydrocarbon). **Stationary phase:** This is the material on the chromatography plates or in the chromatography column through or over which the analytical mixture passes. The stationary phase is often a siliceous material coated with an involatile oil. **Flame ionisation detector:** this is essentially a small gas burner in which the separated components are combusted. Measured variations in electrical conductivity, as the components are burnt in the detector, are used to record the presence and quantity of the separated components. **Retention time:** This is the time it takes for a component to pass through a chromatography column and into a detector.

	<u>ir (<math>\text{cm}^{-1}</math>)</u>	<u>pmr (ppm)</u>
CH <sub>3</sub> CHO (ethanal) CHO	1700	9
C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> OH (phenylmethanol) OH	3400	about 2.5 but variable since concentration dependant)
C <sub>6</sub> H <sub>5</sub> -		7.5
CH <sub>3</sub> COOH (ethanoic acid) -COOH	3500 (v. broad)	12
C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub> (benzenamine) C <sub>6</sub> H <sub>5</sub> -		7.5
NH <sub>2</sub> -	double peak (3500 - 3400)	about 4 but concentration dependant

9.

Also known as the sodium fusion test. Used to convert covalently bonded halogen, nitrogen, phosphorus and sulphur into anions which can be detected and identified by applying simple inorganic analysis.

10. Absence of: amines, amides, haloalkanes and sulphur containing groups.

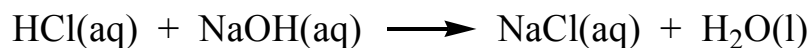
Presence of: carbonyl group (as in aldehydes and ketones), aldehyde group, CH<sub>3</sub>CO- group and unsaturation, probably aromatic.

### Test 36 (answers): Theme: Practical work - titrimetric analysis-1.

1. Burette (eg, 50 cm<sup>3</sup>), pipette (eg, 25 cm<sup>3</sup>), titration flasks (eg, 3 x 250 cm<sup>3</sup>), white tile, burette stand, dropping bottle of suitable indicator, wash bottle of distilled water, pipette filler.
2. Laboratory coat (to protect against splashes of reagents on clothes and skin). Safety spectacles or goggles. Pipette filler (do not suck reagent into pipette by mouth). Never stand on a stool to read the burette (lower the burette to a convenient level). Plastic gloves (these are usually available although they are not often used unless you have particularly sensitive skin). If you splash a reagent on your skin wash it off *immediately* with plenty of cold clean water.
3. (i) any common acid-base indicator.  
(ii) phenolphthalein  
(iii) methyl orange
4. Using the pipette: If for example dilute hydrochloric acid is being measured out the acid meniscus must be *exactly* on the graduation line on the stem of the pipette. Acid must not be lost as the pipette is moved during transference from storage vessel to titration flask. There must be no drips hanging from the tip of the pipette during transference. The pipette must be allowed to empty properly and the tip of the pipette touch to the surface of the liquid in the titration flask so that the correct amount of residual acid is left in the pipette. The pipette must be rinsed with the acid before being filled.
5. Rinse the burette with the reagent which it is to contain before filling. Make sure the burette is filled properly, ie, the tip, below the tap, must be full of reagent and must not contain air pockets. Record the position of the meniscus, in the burette accurately. Position a white card behind the burette so that the graduations can be seen clearly when taking a reading. Double check readings before and after delivery of reagent.
6. (ii). If the reading is in close agreement with your other titre values, average it with the rest.
7. So that the colour changes can be seen clearly (particularly near the end-point).
8. Abort the titration and start again with a clean burette.
9. So that the burette is not damaged when it is tightened in the jaws of the clamp and on those occasions when it accidentally slips down to the base of the stand!
10. Rinse with clean water and return to the prep room for cleaning and storage.

**Test 37 (answers): Theme: Practical work - titrimetric analysis-2**

1.

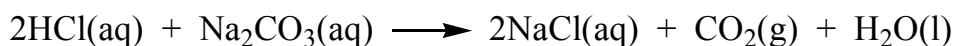


25 cm<sup>3</sup> 0.105M HCl, ie,  $(25/1000 \times 0.105) = 2.625 \times 10^{-3}$  mol

mol of NaOH reacting in the titration =  $2.625 \times 10^{-3}$

mol NaOH per dm<sup>3</sup> =  $1000/23.25 \times 2.625 \times 10^{-3} = 0.113 \text{ mol dm}^{-3}$

2.



mol HCl used in titration =  $(26.05/1000 \times 0.105) = 2.735 \times 10^{-3}$  mol

mol of sodium carbonate reacted in the titration =  $0.5 \times 2.735 \times 10^{-3}$  mol

molarity of Na<sub>2</sub>CO<sub>3</sub> solution =  $1000/25 \times 0.5 \times 2.735 \times 10^{-3}$

$$= 5.47 \times 10^{-2} \text{ mol dm}^{-3}$$

Since the relative molecular mass of Na<sub>2</sub>CO<sub>3</sub> is 106, grams of carbonate per 250 cm<sup>3</sup>

$$= (5.47 \times 10^{-2} \times 106) / 4 = 1.45\text{g}$$

3.

16.15 cm<sup>3</sup>

mol of HCl used in titration =  $(16.15/1000 \times 0.1) = 1.615 \times 10^{-3}$  mol

mol of carbonate reacted in the titration =  $0.5 \times 1.615 \times 10^{-3}$  mol

molarity of sodium carbonate solution =  $1000/25 \times 0.5 \times 1.615 \times 10^{-3} \text{ mol dm}^{-3}$

$$= 3.23 \times 10^{-2} \text{ mol dm}^{-3}$$

but molarity of carbonate solution =  $(1 \times 4) / (106 + 18x)$

therefore,  $[(1 \times 4) / 106 + 18x] = 3.23 \times 10^{-2}$

from which  $x = 0.99$

therefore Na<sub>2</sub>CO<sub>3</sub> xH<sub>2</sub>O = Na<sub>2</sub>CO<sub>3</sub>. H<sub>2</sub>O (ie,  $x = 1$ )

**Test 38 (answers): Theme: Practical work - titrimetric analysis - 3.**

1.

$$\begin{aligned}\text{mol NaOH used in the titration} &= (25.90/1000 \times 0.1) = 2.59 \times 10^{-3} \text{ mol} \\ \text{mol of HX reacting} &= 2.59 \times 10^{-3} \text{ mol}\end{aligned}$$

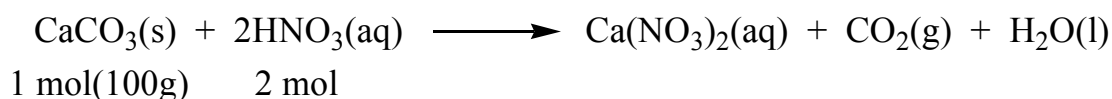
$$\text{Therefore concentration of HX} = 1000/25 \times 2.59 \times 10^{-3} \text{ mol dm}^{-3}$$

$$\text{However, molarity of HX} = (2.50 \times 4) / \text{molar mass}$$

$$\text{Therefore, } (2.50 \times 4) / \text{molar mass} = 1000/25 \times 2.59 \times 10^{-3}$$

$$\text{molar mass} = (10 \times 25) / 2.59 = 96.53 \text{ g mol}^{-1}$$

2.



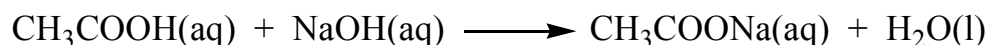
$$\text{mass of CaCO}_3 \text{ used} = (2.50 - 1.15) \text{ g} = 1.35 \text{ g}$$

$$\text{mol of CaCO}_3 \text{ used} = 1.35/100 = 1.35 \times 10^{-2}$$

$$\text{mol of HNO}_3 \text{ reacted} = 2 \times 1.35 \times 10^{-2} = 2.70 \times 10^{-2}$$

$$\text{molarity of the HNO}_3 = (1000/25) \times 2.70 \times 10^{-2} = 1.08 \text{ mol dm}^{-3}$$

3.



$$\text{mol of NaOH used in the titration} = (20.25/1000) \times 0.10 = 2.025 \times 10^{-3} \text{ mol}$$

$$\text{mol of CH}_3\text{COOH reacted in the titration} = 2.025 \times 10^{-3} \text{ mol}$$

$$\begin{aligned}\text{Therefore, mol CH}_3\text{COOH per dm}^3 \text{ of diluted vinegar} &= (1000/25) \times 2.025 \times 10^{-3} \\ &= 0.081 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Therefore molarity of the original vinegar with respect to ethanoic acid} &= 10 \times 0.081 \\ &= 0.81 \text{ mol dm}^{-3}\end{aligned}$$

$$\text{Therefore g of CH}_3\text{COOH per 100 g of vinegar} = 60 \times 0.81 \times 0.1 = 4.86 \text{ g}$$

## Test 39 (answers): Theme: Practical work - titrimetric analysis - 4.

### 1. Purple

Molar mass  $\text{KMnO}_4 = 39 + 54.9 + 64 = 157.9 \text{ g mol}^{-1}$

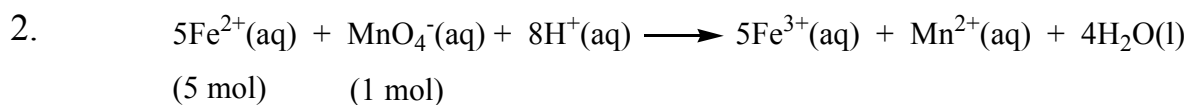
Therefore,  $0.02 \times 157.9 = 3.158 \text{ g}$

It stains skin and clothes brown. If spilt in the skin wash off immediately.

It is a powerful oxidising agent.

Wear eye protection when using.

Redox titrations.



$\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O} = 392 \text{ g mol}^{-1}$

molarity of iron(II) solution:  $(9.8 \times 4)/392 = 0.10 \text{ mol dm}^{-3}$

mol of iron(II) used in the titration =  $(25/1000) \times 0.1 = 2.5 \times 10^{-3} \text{ mol}$

mol of permanganate reacted in the titration =  $1/5 \times 2.5 \times 10^{-3} \text{ mol}$

mol of permanganate per  $\text{dm}^3 = 1000/23.40 \times 2.5 \times 10^{-3} \text{ mol}$   
 $= 0.107 \text{ mol}$   
ie.,  $0.107 \text{ mol dm}^{-3}$

A *primary standard* is a reagent which can be obtained in high purity and can be weighed and used directly to make up a standard solution which can then be used to standardise a solution of another reagent.

Properties:

1. A substance of high purity (eg, 99.99%).
2. A substance which dissolves fairly readily in water.
3. A stable substance (ie, does not deteriorate or change in mass when exposed to air)
4. A substance which has a relatively high molar mass.
5. A substance which reacts reliably according to a given stoichiometric equation.

## Test 40 (answers): Theme: Practical work - titrimetric analysis - 5

1.

$$\text{mol of permanganate used in titration} = \frac{31.25}{10^3} \times 0.02 = 6.25 \times 10^{-4} \text{ mol}$$

$$\text{mol of hydrogen peroxide reacting} = \frac{5}{2} \times 6.25 \times 10^{-4} = 1.563 \times 10^{-3} \text{ mol}$$

$$\begin{aligned} \text{mol of hydrogen peroxide in } 250 \text{ cm}^3 &= 10 \times 1.563 \times 10^{-3} \text{ mol} \\ &= \text{mol H}_2\text{O}_2 \text{ in the original } 25 \text{ cm}^3 \text{ of mouthwash} \end{aligned}$$

$$\begin{aligned} \text{Therefore, mol per dm}^3 \text{ of mouthwash} &= 1000/25 \times 1.563 \times 10^{-2} \\ &= 0.625 \text{ mol} \end{aligned}$$

$$\text{g per dm}^3 = 20 \times 0.625 = 12.50 \text{ g}$$

$$\% = (12.50/1000) \times 100 = 1.25$$

Used in rocket fuel and for bleaching textiles and paper.

2.

$$\text{mol of permanganate per } 25.00 \text{ cm}^3 = 25/1000 \times 0.02 = 5 \times 10^{-4} \text{ mol}$$

$$\begin{aligned} \text{mol of nitrite reacting} &= 2.5 \times 5 \times 10^{-4} \\ &= 1.25 \times 10^{-3} \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{mol of nitrite in } 250 \text{ cm}^3 \text{ of solution} &= (250/24.85) \times 1.25 \times 10^{-3} \\ &= 0.01258 \text{ mol} \end{aligned}$$

$$\% \text{ purity} = \frac{(0.01258 \times 69)}{1} \times 100 = 86.80$$

The procedure ensures that the nitrite reacts quickly and quantitatively with the permanganate rather than being prematurely decomposed by contact with acid.



## Test 41 (answers): Theme: Practical work - titrimetric analysis - 6

1.

$$\text{mol of permanganate used in titration} = (26.25/1000 \times 0.02) = 5.25 \times 10^{-4} \text{ mol}$$

$$\text{mol of oxalate reacted} = 5/2 \times 5.25 \times 10^{-4} = 1.313 \times 10^{-3} \text{ mol}$$

$$\text{mol of oxalate per dm}^3 = 1000/25 \times 1.313 \times 10^{-3} = 0.0525 \text{ mol}$$

$$\text{molarity} = 0.053 \text{ mol dm}^{-3}$$

The reaction is slow at room temperature. The solution in the titration flask needs to be maintained at about 60°C during the titration. About 20 cm<sup>3</sup> of dilute sulphuric acid should be added to the contents of each titration flask prior to titration.

Avoid skin contact with hot titrant and with the permanganate solution.  
Oxalate solutions are poisonous.

2. Orange.

Molar mass: 294.22 g

$$\text{molarity of the dichromate solution} = (4 \times 1.226)/294.22 = 0.01667 \text{ mol dm}^{-3}$$

$$\text{mol of dichromate used in titration} = 26.85/1000 \times 0.01667 = 4.476 \times 10^{-4} \text{ mol}$$

$$\text{mol of iron(II) reacted} = 6 \times 4.476 \times 10^{-4} = 2.685 \times 10^{-3} \text{ mol}$$

$$\text{molarity of the iron(II) solution} = 1000/25 \times 2.685 \times 10^{-3} = 0.107 \text{ mol dm}^{-3}$$

Phosphoric acid: it forms a complex ( [Fe(HPO<sub>4</sub>)]<sup>+</sup> ) with the iron(III). This ensures that the indicator works properly and that the colour changes are sharp.

To begin with the indicator imparts a green colour to the contents of the titration flask. Near the end point the solution is blue-green and at the end point intense purple or violet.

Permanganate is the stronger oxidising agent.

It's easier to read the burette since the dichromate solution is usually clearer (more transparent).

Dichromate solution is more stable; standard solutions keep better providing they are in sealed flasks.

Dichromate titrations can be performed in dilute hydrochloric acid (1 - 2 M).

Dichromate solutions are not as susceptible to reduction by organic material.

Standard dichromate solutions can be made up by direct weighing of the pure material (this is not possible in the case of potassium permanganate).

## Test 42 (answers): Theme: Practical work - further titrimetric analysis-7

1.

$$\text{mol of silver nitrate used} = (150/1000) \times 0.10 = 1.5 \times 10^{-2} \text{ mol}$$

$$\text{mol of KCNS used in the titration} = (15.65/1000) \times 0.10 = 1.565 \times 10^{-3} \text{ mol}$$

$$\begin{aligned} \text{mol of KCNS required per } 250 \text{ cm}^3 &= (250/25) \times 1.565 \times 10^{-3} \text{ mol} \\ &= 7.825 \times 10^{-3} \text{ mol} \end{aligned}$$

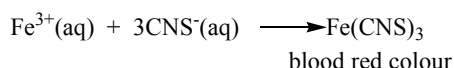
$$\begin{aligned} \text{mol of silver nitrate reacted with sodium chloride} &= 1.5 \times 10^{-2} - 0.7825 \times 10^{-2} \text{ mol} \\ &= 0.7175 \times 10^{-2} \text{ mol} \end{aligned}$$

$$\text{mol of sodium chloride reacted} = 0.7175 \times 10^{-2} \text{ mol}$$

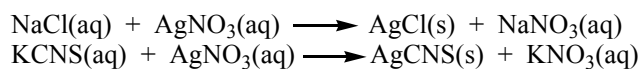
$$\text{mass of sodium chloride reacted} = 0.7175 \times 10^{-2} \times 58.5 \text{ g}$$

$$\begin{aligned} &= 41.97 \times 10^{-2} \text{ g} \\ &= 0.4197 \text{ g} \end{aligned}$$

$$\% \text{ purity} = (0.4197/0.450) \times 100 = 93.27\%$$



Because silver thiocyanate is less soluble than iron(III) thiocyanate and is therefore precipitated first.

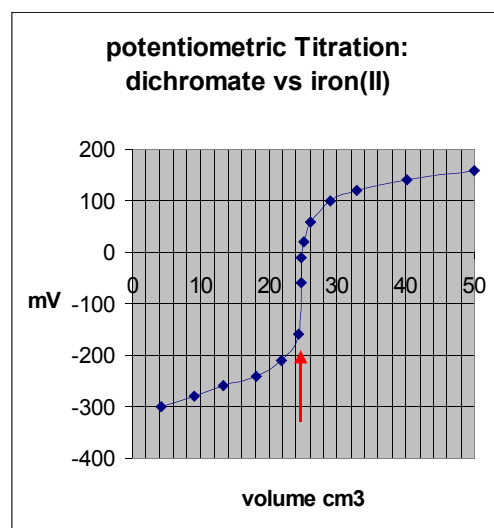


2. End point =  $24.75 \text{ cm}^3$

$$\begin{aligned} \text{mol of dichromate used in the titration} &= (24.75/1000) \times 0.017 \text{ mol} \\ &= 4.21 \times 10^{-4} \text{ mol} \end{aligned}$$

$$\text{mol iron(II) reacted} = 6 \times 4.21 \times 10^{-4} = 2.526 \times 10^{-3} \text{ mol}$$

$$\text{molarity of iron(II) solution} = (1000/25) \times 2.526 \times 10^{-3} = 0.101 \text{ mol dm}^{-3}$$



### Test 43 (answers): Theme: Practical work - Inorganic analysis - 1

1.

TEST	OBSERVATION	INFERENCE
A small amount of A was taken up on a platinum wire and heated in a hot bunsen flame.	A bright yellow-orange colour was observed.	This is characteristic of a sodium salt.
A small amount of A was heated in a clean, dry, test tube	A colourless liquid condensed on the cool part of the tube.	Possibly water from decomposition of a hydrated salt.
A small amount of A was dissolved in distilled water. Dilute hydrochloric acid was added.	No change was observed. No gas evolved.	Not a carbonate or hydrogencarbonate. Not a sulphite.
A small amount of A was dissolved in distilled water. The solution was acidified with dilute nitric acid and dilute silver nitrate added.	No change was observed.	Not a chloride, bromide or iodide.
A small amount of A was dissolved in distilled water. The solution was acidified with dilute hydrochloric acid and dilute barium chloride added.	A white precipitate was obtained.	The salt is a sulphate.
	Hydrated Sodium sulphate	
	$\text{Na}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ (x is possibly 10)	

2.

TEST	OBSERVATION	INFERENCE
Performed flame test on pure substance B.	Gave a lilac coloured flame.	Indicative of potassium.
The salt B was freely soluble in distilled water. A dilute solution was treated with dilute nitric acid and dilute silver nitrate.	A yellow precipitate was formed. This was insoluble in ammonia solution.	This precipitate is silver iodide, indicating iodide ion in salt B.
An aqueous solution of B was treated with chlorine water.	The mixture acquired an immediate brown colouration. The solution turned starch paper blue.	The brown colour is due to iodine, indicating iodide in salt B.
	Name of B:	Potassium iodide
	Formula of B:	KI

**Test 44 (answers): Theme: Practical work - Inorganic Analysis - 2**

1.

TEST	OBSERVATION	INFERENCE
Pure substance C was heated strongly, on a platinum wire, in a bunsen flame.	An apple green colour was observed.	C is a barium salt.
Substance C is a white crystalline solid insoluble in water. However, it dissolves in dilute hydrochloric acid.	Effervescence was observed. The gas evolved was colourless and odourless and turned lime water milky.	The gas was carbon dioxide. Substance C was a group II carbonate.
A small amount of C was dissolved in dilute hydrochloric acid. 2 cm <sup>3</sup> of dilute sodium sulphate was added.	A white precipitate was formed which was insoluble in excess hydrochloric acid.	The precipitate was barium sulphate.
	Name of C:	Barium carbonate
	Formula of C:	BaCO <sub>3</sub>

2.

TEST	OBSERVATION	INFERENCE
Pure substance D was heated strongly, on a platinum wire, in a bunsen flame.	A brick-red colour was observed.	D is a calcium salt.
Substance D is a white crystalline solid soluble in water. Dilute sulphuric acid was added to the solution.	A white precipitate was formed..	The white precipitate was calcium sulphate.
A small amount of D was dissolved in distilled water and 2 cm <sup>3</sup> of dilute sodium carbonate was added.	A white precipitate was formed .	The precipitate was calcium carbonate.
A small amount of D was dissolved in distilled water. The solution was acidified with dilute nitric acid and 2 cm <sup>3</sup> of dilute silver nitrate added.	A white precipitate was formed which was soluble in dilute ammonia solution.	Chloride is indicated.
	Name of D:	Calcium chloride
	Formula of D:	CaCl <sub>2</sub>

**Test 45 (answers): Theme: Practical work - Inorganic Analysis - 3**

1.

TEST	OBSERVATION	INFERENCE
Pure substance E was heated strongly, on a platinum wire, in a bunsen flame.	A green colour was observed.	E is a barium or copper salt.
Substance E is a white crystalline solid. It was dissolved in water.	The solution was blue and was warm to the touch.	E is a anhydrous copper salt.
A small amount of E was dissolved in distilled water. The solution was acidified with hydrochloric acid and dilute barium chloride added.	A whitish-blue precipitate was formed which was insoluble in excess acid.	The precipitate is barium sulphate. E is a sulphate.
	Name of E:	Anhydrous copper sulphate
	Formula of E:	CuSO <sub>4</sub>

2.

TEST	OBSERVATION	INFERENCE
Pure substance F was heated strongly, on a platinum wire, in a bunsen flame.	A whitish flame colour was observed.	F is a heavy metal salt.
Substance F was a pale green crystalline solid soluble in water. Dilute sodium hydroxide was added to the solution.	A green precipitate was formed. This turned brownish on standing.	The green precipitate is iron(II) hydroxide which slowly turns brown as it is oxidised to the iron(III) hydroxide.
A small amount of F was heated strongly in a borosilicate glass tube.	A colourless liquid formed on the cool part of the tube, a reddish brown solid was formed and acidic, brown, fumes were evolved.	The liquid is water liberated from a hydrated salt. The brown solid is iron(III) oxide and the brown fumes are due to nitrogen(IV) oxide. F is iron(II) nitrate.
A small amount of F was heated with Devarda's alloy and sodium hydroxide solution.	A pungent smelling gas was evolved which turned damp red litmus blue. The gas gave white fumes with the vapour from concentrated hydrochloric acid.	The gas is ammonia. It is formed by the reduction of nitrate ion present in F.
	Name of F:	Hydrated Iron(II) nitrate
	Formula of F:	Fe(NO <sub>3</sub> ) <sub>2</sub> xH <sub>2</sub> O

**Test 46 (answers): Theme: Practical work - Organic Analysis - 1**

Complete the inference columns and write a conclusion, name &/or formula as required.

1.

TEST	OBSERVATION	INFERENCE
Pure organic substance A was combusted on a crucible lid.	It burnt with a smokey flame.	Substance A is unsaturated (possibly an alkene since it did not burn with a <u>very</u> smokey flame like an aromatic compound).
Substance A was shaken with some bromine water.	The bromine water was decolourised.	Substance A is unsaturated, possibly an alkene.
Substance A was shaken with dilute potassium permanganate solution.	The permanganate solution was decolourised.	Substance A is unsaturated, possibly an alkene.
Quantitative analysis showed that A reacted with hydrogen gas.	1 mole of A reacted with 1 mole of hydrogen gas	Substance A contains 1 carbon-carbon double bond per molecule.
	Conclusion:	Substance A is a simple alkene.

2.

TEST	OBSERVATION	INFERENCE
Substance B is a colourless liquid with a pleasant odour. A small amount was burnt on a crucible lid.	It burnt with a clean flame. The odour is alcoholic.	Substance B is a saturated aliphatic compound; possibly an alcohol such as ethanol.
Substance B was added to water.	B mixed with water in all proportions. The solution became warm.	Substance B is simple polar substance. Could be a simple alcohol or carbonyl compound.
Substance B was added to Brady's reagent.	There was no change (no apparent reaction).	B is not an aldehyde or ketone.
Substance B was mixed with potassium dichromate in dilute sulphuric acid. The mixture was warmed in hot water.	Over a period of a few minutes the mixture changed colour from yellow-orange to green. A faint smell of over ripe apples was detected.	B has undergone oxidation. The odour could be due to ethanal in which case B could be the primary alcohol, ethanol.
The above test (test 4) was repeated and the vapours drawn into a test pipette and expelled into Tollens reagent.	A black precipitate and silver mirror was formed.	An aldehyde is present in the reaction vapours supporting the possibility that B is ethanol.
	Name of B:	ethanol
	Formula of B:	CH <sub>3</sub> CH <sub>2</sub> OH

**Test 47 (answers): Theme: Practical work - Organic Analysis - 2**

Complete the inference columns and write a conclusion, name &/or formula as required.

1.

TEST	OBSERVATION	INFERENCE
Substance C is a colourless liquid. It was added to water.	Substance C mixes with water in all proportions. It has a vinegary odour. The solution turns blue litmus red.	C is a polar substance. Its odour suggests ethanoic acid (acetic acid). The litmus test indicates acid.
A few drops of C was added to 10% sodium carbonate solution.	Effervescence occurred. The gas evolved turned lime water milky.	The gas was carbon dioxide. This suggests that C is a carboxylic acid.
Six drops of C were added to 1 cm <sup>3</sup> of ethanol in a test tube. A drop of concentrated sulphuric acid was added and the mixture warmed in warm water.	When the contents of the tube were poured into water in a beaker a strong fruity odour was apparent.	This helps to confirm that C is ethanoic acid since the acid forms esters with alcohols. In this case ethyl ethanoate is formed.
	Write a name for C:	Ethanoic acid
	Write a formula for C:	CH <sub>3</sub> COOH

2.

TEST	OBSERVATION	INFERENCE
Substance D is yellowish, oily, liquid. It was added to water in a test tube.	Substance did not appear to dissolve in the water however, pH paper indicated that the aqueous solution was slightly alkaline.	Since the solution was alkaline D could be an amine. It is not a simple aliphatic amine since these are fairly soluble in water. I could be an aromatic amine.
A drop of D was burned on a crucible lid.	A luminous sooty flame was produced.	Highly unsaturated. Possibly aromatic.
A few drops of D was added to 1 cm <sup>3</sup> of ethanoic anhydride (acetic anhydride). The mixture was shaken in a test tube.	A white precipitate was formed. This was filtered off, purified, and its melting point measured (mp 114°C).	The white precipitate is likely to be the acetyl derivative of an aromatic amine. Comparing the mp with literature values indicates that the derivative is acetanilide and that D is benzenamine (aniline).
A few drops of D was shaken with bromine water.	A yellowish precipitate was formed.	The precipitate is likely to be tri-bromoaniline.
	Write a name for D:	Benzenamine (or aniline)
	Write a formula for D:	C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>

**Test 48 (answers): Theme: Practical work - Organic analysis - 3**

Complete the inference column and the conclusions.

1.

TEST	OBSERVATION	INFERENCE
Substance E is a white crystalline solid (mp 137°C). Test solubility in water.	It is soluble in <u>hot</u> water. Giving an acidic solution.	Could be an aromatic carboxylic acid (note: benzenecarboxylic acid is soluble in hot water and sparingly soluble in cold).
Burn E on a crucible lid.	Very smokey, luminous flame.	Highly unsaturated, aromatic.
Following the Lassaigne procedure E was fused with sodium and then digested in distilled water. The filtrate was tested for nitrogen, halogens, & sulphur.	The tests indicated that, apart from carbon, hydrogen and oxygen the only other element present was chlorine.	E is chlorinated. Considering the previous inference, E is a chlorinated carboxylic acid.
Infra-red spectroscopy	Sharp, medium sized peaks just above 3000 cm <sup>-1</sup> . Very broad absorption 3500-2700 cm <sup>-1</sup> .	Aromatic C-H stretch. Hydroxyl absorption (in the COOH group).
Substance E was refluxed with ethanol and a few drops of concentrated sulphuric acid. The reaction mixture was distilled and a pleasant smelling liquid was isolated.	The distillate boiled at 243°C and gave a positive ester test (alcoholic hydroxylamine hydrochloride, methanolic KOH, boil, acidify with HCl and add a drop or two of iron(III) chloride - deep red or purple indicates ester).	Ethyl ester of a carboxylic acid therefore E is a carboxylic acid. The boiling point suggests that the ester is the ethyl ester of 2-chlorobenzenecarboxylic acid. The melting point of E supports this conclusion since the mp corresponds with that of 2-chlorobenzenecarboxylic acid..
	Name of E:	2-chlorobenzenecarboxylic acid.
	Formula of E:	ClC <sub>6</sub> H <sub>4</sub> COOH (1:2)

2.

TEST	OBSERVATION	INFERENCE
Substance F: Very cautiously smell. Test solubility in water.	It is highly volatile. It has a very pungent odour. Soluble in water.	Odour, solubility and volatility suggests ethanal (acetaldehyde).
Infra-red spectroscopy.	Intense absorption at 1727 cm <sup>-1</sup> . Medium absorption at 2733 cm <sup>-1</sup> . Medium to strong absorption at 2846 cm <sup>-1</sup> .	Indicates carbonyl group. Indicates aldehydic proton. Indicates methyl/methylene group(s).
Nuclear magnetic resonance spectroscopy.	Singlet peak at 2.20 ppm (integration = 3 units) Singlet peak at 9.79 ppm (integration = 1 unit)	Methyl group Aldehydic proton.
	Name of F: Formula of F:	Ethanal (acetaldehyde) CH <sub>3</sub> CHO



**Test 49 (answers): Theme: Practical work - Organic analysis - 4**

Complete the inference column and identify G.

1.

TEST	OBSERVATION	INFERENCE
Substance G is a colourless liquid. Test its solubility in water.	Slightly soluble in water giving a neutral solution. G has an odour of roses.	It contains polar group(s) but is aromatic or has a medium sized hydrocarbon fragment reducing its solubility in water. It is not acidic or basic.
Burn a few drops of G on a crucible lid.	It burns with a very smokey flame.	G is probably aromatic (ie, high carbon to hydrogen ratio).
Apply Lassaigne test.	G does not contain halogens, nitrogen or sulphur.	G is a relatively simple aromatic alcohol or carbonyl compound.
Apply quantitative C, H & O analysis. Also mass spectrometry analysis.	C = 78.69%, H = 8.19%, O = 13.11%. Relative molecular mass = 122	Molecular formula = $C_8H_{10}O$
Esterify with ethanoic acid and a few drops of concentrated sulphuric acid.	Following work up and distillation a pleasant smelling, colourless, liquid was obtained boiling at 232°C.	G is an alcohol and the ethanoate ester may be phenylethyl ethanoate (by comparing the boiling point with literature values).
Infra-red spectroscopy.	Broad intense peak centred at 3500 $cm^{-1}$ . Strong peaks just below 3000 $cm^{-1}$ . Sharp peaks just above 3000 $cm^{-1}$ .	Hydroxyl group as in an alcohol. $CH_3/CH_2$ group(s).  Aromatic C-H stretching.
Pmr spectroscopy.	Singlet at 7.2 ppm (integration = 5 units) Triplets at 2.8 and 3.8 ppm (integration = both sets 2 units each). Singlet at 2.1 ppm (integration = 1 unit).	Phenyl group.  Two adjacent methylene groups.  One hydroxyl group.
	Name of G:	2-phenylethanol
	Formula of G:	$C_6H_5CH_2CH_2OH$

**Test 50 (answers): Theme: Practical work - Organic analysis - 5**

Complete the inference column and identify H.

1.

TEST	OBSERVATION	INFERENCE
Substance H is a colourless liquid (bp 185°C). Solubility in water.	Partially soluble in water. The solution was alkaline to pH paper.	A polar substance, possibly a low molecular mass amine.
Burn on a crucible lid.	Very smokey, luminous, flame.	Unsaturated. Possibly aromatic.
Lassaigne analysis.	Positive result for nitrogen. Negative results for halogen and sulphur.	Indicates amine, amide or nitro compound. (amine is the most likely considering the result of test 1 above).
Shake a few drops of H with 1 cm <sup>3</sup> of benzoyl chloride and 2 cm <sup>3</sup> of cold, dilute, sodium hydroxide.	Grey-white precipitate.	This is evidence that H is an amine and has been benzoylated.
Add a few drops of H to an ice cold solution of nitrous acid.	Efforescence occurred. The gas was colourless & neutral.	The gas was probably nitrogen. This result is typical of primary amines.
Quantitative analysis.  Mass spectrometry:	Carbon = 78.50%, H = 8.41%, N = 13.08%.  Mol. Ion peak = 107 Base peak = 106	Emp. Formula: C <sub>7</sub> H <sub>9</sub> N  Mol. Form: C <sub>7</sub> H <sub>9</sub> N C <sub>6</sub> H <sub>5</sub> CH=NH <sub>2</sub> <sup>+</sup>
Infra-red spectroscopy:	3400 cm <sup>-1</sup> 3030 - 3090 cm <sup>-1</sup> 2860 - 2930 cm <sup>-1</sup>	NH <sub>2</sub> Aromatic C-H Aliphatic CH <sub>2</sub>
Proton magnetic resonance spectroscopy:	Singlet at 1.50 ppm (integration = 2 units) Singlet at 3.80 ppm (integration = 2 units) Peaks centred at 7.35 ppm (Integration = 5 units)	NH <sub>2</sub>  CH <sub>2</sub> (between Ph and NH <sub>2</sub> )  C <sub>6</sub> H <sub>5</sub>
	Name of H:	Aminophenylmethane (benzylamine)
	Formula of H:	C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> NH <sub>2</sub>

**Test 51 (answers): Theme: Practical work - Organic analysis - 6**

Complete the inference column and identify I.

1.

TEST	OBSERVATION	INFERENCE
Substance I is a colourless liquid. Bp 173°C. Test solubility in water.	I has an ester-like odour. It is insoluble in water.	It could be an ester. It is neither acidic or basic. It could be an ester or ketone.
Burn I on a crucible lid.	I burns readily with a relatively clean, luminous, flame.	Aliphatic.
Test I with Brady's reagent.	Yellow-orange precipitate. Following recrystallisation and drying it melted at 84°C.	The molecular structure of I contains a carbonyl group (possibly a ketone on the basis of previous tests).
Add a few drops of I to bromine solution and shake.	Bromine solution was decolourised (red-brown to colourless).	Indicates unsaturation.
Quantitative analysis. Mass spectrometry.	C = 76.19%, H = 11.11%, O = 12.70%. Molecular ion peak = 126.	Empirical formula = C <sub>8</sub> H <sub>14</sub> O Molecular formula = C <sub>8</sub> H <sub>14</sub> O
Infra red spectroscopy	Intense absorption at 1720 cm <sup>-1</sup> . Intense absorption just below 3000 cm <sup>-1</sup> . No absorption immediately above 3000 cm <sup>-1</sup> .	Indicates carbonyl group as in ketone. Indicates CH <sub>3</sub> /CH <sub>2</sub> No aromatic C-H.
Proton magnetic resonance	Peak at 1.65 ppm (integration = 6 units). Singlet at 2.13 ppm (integration = 3 units). Peak at 2.25 ppm (integration = 2 units). Peak at 2.46 ppm (integration = 2 units). Peak at 5.07 ppm (integration = 1 unit).	2 methyl groups attached to the same carbon atom. 1 isolated methyl group. A methylene group. A methylene group. A single proton attached to an unsaturated carbon atom.
	Name of compound I:  Formula of compound I:	6-methylhept-5-en-2-one (sulcatone)  (CH <sub>3</sub> ) <sub>2</sub> C=CHCH <sub>2</sub> CH <sub>2</sub> COCH <sub>3</sub>